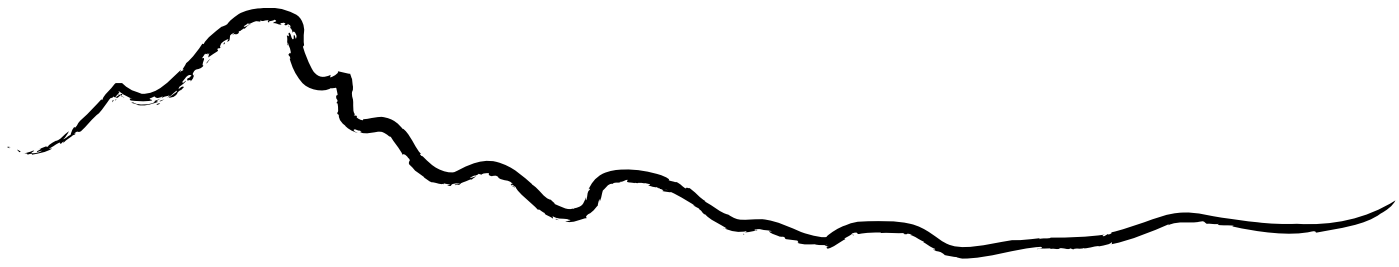
NLCS

A Decade of Discovery

National Landscape Conservation System



Conserve Protect Restore Discover

NATIONAL SYSTEM OF PUBLIC LANDS

Welcome to the Decade of Discovery Science Symposium.

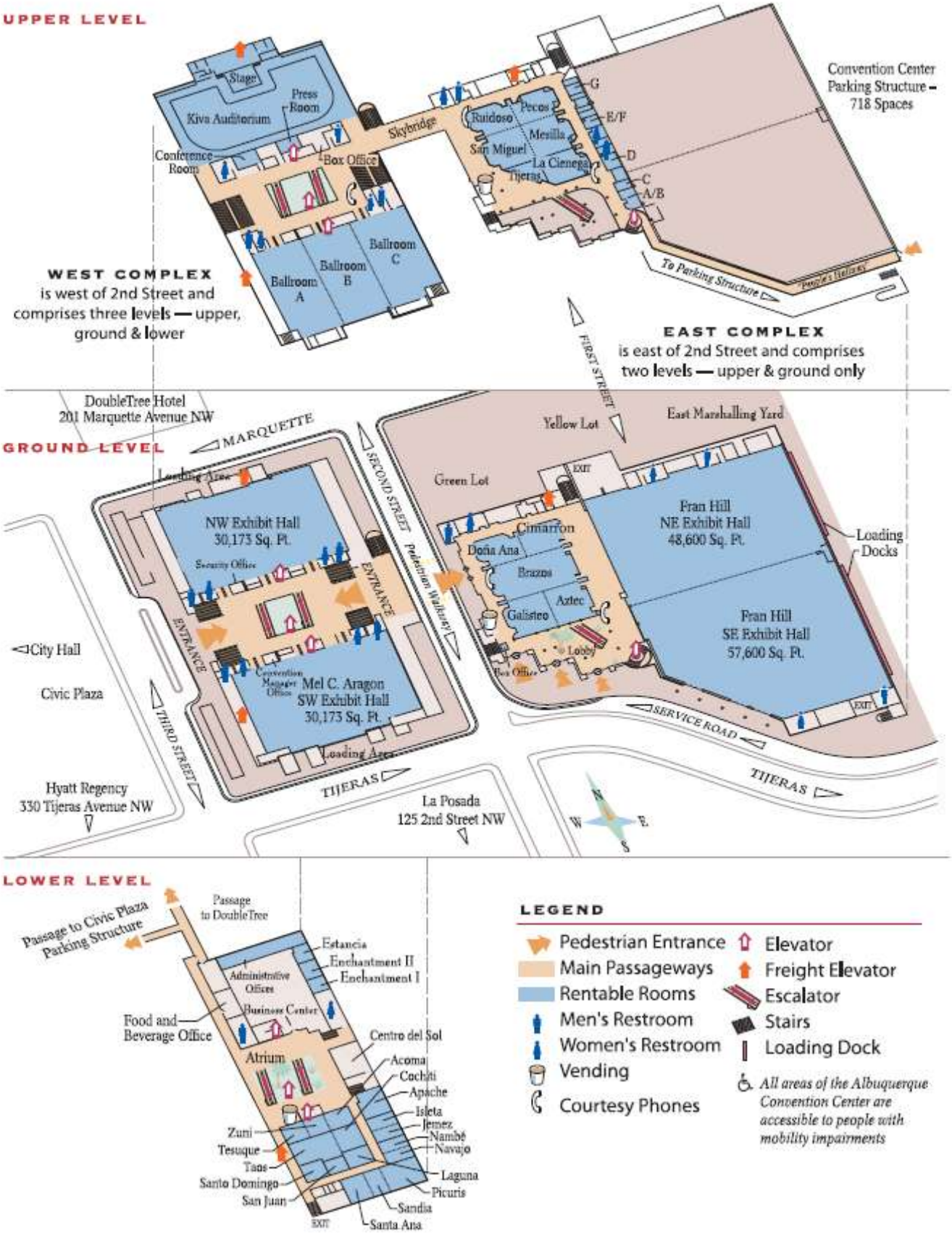
This binder has five main categories:

I. Document Orientation
II. Map of the Albuquerque Convention Center
III. Statement on sustainability
IV. Table of Contents
V. Abstracts

Black text is for presentations and blue text is for posters

Abstracts are organized by discipline and alphabetical by author in each grouping

Albuquerque Convention Center Floor Plan



A DECADE OF DISCOVERY

NATIONAL LANDSCAPE CONSERVATION SYSTEM

BUREAU OF LAND MANAGEMENT

SCIENCE SYMPOSIUM

– PROMOTING SUSTAINABILITY-

One of the key objectives of the *Decade of Discovery*, National Landscape Conservation System Science Symposium will be to promote and support sustainable practices. Numerous steps have been taken to help achieve this objective. Key steps include:

- Holding the Symposium in Albuquerque New Mexico. Albuquerque has received numerous honors and awards for its comprehensive sustainability plan, which provides a vision and tools for energy conservation, clean energy production and use, and conservation technologies. The City of has been selected as the winner of the inaugural Siemens Sustainable Community Award.
- Holding the Symposium at the Albuquerque Convention Center. This center is committed to a wide variety of sustainable practices to reduce, reuse, and recycle. Some of these practices include:

    - A commitment to use food products from local farmers and producers
    - Options to create menus featuring indigenous, local foods
    - Low-water plants and xericape landscaping
    - An energy-smart HVAC system which provided effective and efficient heating and cooling
    - Not operating lights, air, heat and escalators in non-occupied areas
    - Solar reflective roof coating to reduce the heat load during the summer months
    - Use of environmentally-green housekeeping products Utilizing china, glass and silverware for catered functions
    - Use of compact fluorescent light bulbs in hallways and lobby areas
    - Recycling containers throughout the Center to recycle aluminum and plastic
    - Kitchen grease recycling
    - Recycling 90% of white paper use in the Administration Office
    - Albuquerque Convention Center has just been awarded the 2010 Hospitality Recycling Program of the Year by New Mexico Recycling Coalition and will be honored with a Recyling Achievement Award on June 22nd.

    (Further information regarding The ACC Sustainability Programs can be found at: http://albuquerquecc.com/sustainability/index.php)

- Lodging the Symposium participants at the Hyatt Regency Hotel. The Hotel's sustainability initiatives include waste stream recycling and energy waste minimization and conservation. The Hotel is also within walking distance of the Convention Center.
- Public mass transit is available for Symposium participants to travel from the Convention Center to the New Mexico Museum of Natural History, and is also available for other destination needs; both downtown and throughout the city.
- An intercity "Roadrunner" Rapid Rail is available for pre and post Symposium travel.
- Products provided to Symposium participants will emphasize sustainable materials and practices.

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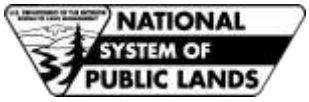

Geology

Snowy River: Walking Hand in Hand with Beauty and Science

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Oral Presentation
Key words: Multidisciplinary Science Assessment, Science Collaboration, Science and Management, Volunteers, Fort Stanton-Snowy River National Conservation Area

Within the BLM managed Fort Stanton Cave system, known and used by Native Americans, white settlers, and modern recreational cavers, lies a glorious new secret buried at her heart…a gleaming "frozen" river of crystalline calcite in a previously unknown passage, *Snowy River*. Brought to light in 2001 by a three person volunteer team, this newly found passage has already yielded the largest continuous speleothem (mineral cave decoration) in the world, over 4.7 miles (7.5km) of a single sparkling deposit. Besides this astonishing natural wonder, the cave contains a dazzling array of other scientific riches touching on questions about past climate and water resources, history of aboveground vegetation, and exotic microorganisms in velvety black coatings on cave walls.

A few decades ago, Fort Stanton Cave was considered virtually a "trash cave" because of extensive vandalism. Dedicated efforts of volunteers and BLM personnel have restored it to its rightful place as a major underground resource managed by BLM. This past year has seen the system given unprecedented recognition and protection by way of the National Landscape Conservation system. The tireless efforts of many have bestowed on us this treasure to protect, to manage, and to study.

I will present initial results of a comprehensive and multidisciplinary scientific study including information about the age of the calcite deposit, history of flooding episodes and resulting mineral deposition, aspects of the lives of the microbial inhabitants, and more. As the pieces of the Fort Stanton Cave/Snowy River puzzle slowly fit together, a picture will emerge not only of the cave itself but also of the greater environment that created and continues to sustain it. This system provides an unprecedented opportunity to study, appreciate, and manage critical nutrient and hydrological connections between surface and subsurface ecosystems and the vital role that caves play in the natural world and our human resource base.

Red Rocks, Concretions, and Weathering Analogs from Earth to Mars

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Oral Presentation
Key words: Sedimentology, Stratigraphy, Diagenesis

Public lands of the Colorado Plateau exhibit exceptional exposures of sedimentary rocks that offer valuable training grounds for earth and planetary scientists. Exposures contain valuable analogue environments for understanding and interpreting similar terrains on Mars. The lack of vegetative cover, the dry climate, and modern wind processes of the desert southwest are conducive to compare to recent satellite imagery of Mars. Few other

terrestrial areas are so accessible, with many analog sedimentary environments such as eolian, fluvial, lacustrine, and spring systems all in close proximity.

The rock exposures contain primary deposits preserving characteristic bedding/stratification and depositional structures. Modifying processes and products such as diagenetic fluid flow, soils and weathering, patterned grounds, and various structural styles are commonly superimposed on the pre-existing primary deposits. The Jurassic Navajo Sandstone of southern Utah contains numerous iron oxide concretions (cemented mineral masses) within ancient wind-blown, cross-bedded dune deposits in sandstone. The concretions and different hues of red and white colors reflect the history of iron cycling and fluid flow through the porous media. The self-organized spheroidal concretions resemble marbles and imply diffusive mass transfer processes. Superimposed weathering crack patterns also reflect different host rock properties: polygonal cracks form in homogenized, massive sandstone; and rectilinear cracks form in strongly cross-bedded, anisotropic sandstone. Similar hematite concretions (dubbed "blueberries") and polygonal crack patterns form in cross-bedded sandstone of the Burns formation in Meridiani Planum, Mars. The Navajo Sandstone examples are useful to interpret the geologic processes of groundwater flow and weathering patterns on wind-blown sedimentary deposits of Mars, even though the geochemistry and mineralogy differ. There are many more scientific explorations, analog comparisons, and sites for mission instrument testing in BLM's spectacular National Landscape Conservation System (NLCS).

Tools to Manage Soil Erosion: Lab Measures of chlorophyll *a* Indicate Biological Soil Crust Presence and the Field Slake Test Indicates Soil Aggregate Stability

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Poster
Key words: Applied Research, Shale Soils, Soil Crust, Salinity, Gunnison Gorge National Conservation Area

Land use management that promotes the aggregation of Mancos Shale derived soils can reduce soil erosion and thus reduce the transportation of salts and sediments into the Upper Colorado River. Salinity in the Colorado River is estimated to cause damages >$330 million annually. We intensively sampled 96 1-m^2 plots on the Mancos Shale derived soils of the Gunnison Gorge National Conservation Area, southwest Colorado, to explore relationships between soil stability and biological, chemical and physical site characteristics. We measured non-visible biological soil crust in the laboratory by quantifying chlorophyll *a* content in surface (top 5mm) soil with a flourometer. We measured soil aggregate stability in the field using the simple slake test. Easily measured field variables explained 45% of the variation in the milligrams of chlorophyll a per gram of soil (regression tree proportional reduction in error = 0.45). Slake test data showed decreased soil stability when erosion features were present at a sample location (ANOVA p=0.02) suggesting the applicability of stability test results to the erosion potential of Mancos Shale derived soils. The best predictor variable for soil aggregate stability was the percent cover of visible biological soil crust. Understanding the importance of biological soil crust in the stabilization of Mancos Shale soils may guide land use planning because biological soil crusts respond to changes in land use. The results of this study may assist in the definition of important ecological or functional thresholds in many arid and semiarid environments.

This work is published in: Carpenter, D.R. and G.W. Chong. 2010. Patterns in aggregate stability of Mancos Shale derived soils. Catena 80:65-73 and Chong, G.W., D.R. Carpenter and J. Belnap. 2006. Non-visible biological soil crusts: ecosystem upstarts – at least when it rains. Published Abstracts: The Ecological Society of America 91st Annual Meeting, August 6-11, 2006, Memphis, TN.

Mancos Shale Landscapes: Science and Management of Black Shale Terrains - Gunnison Gorge Conservation Area

DICK GRAUCH[1], Michele Tuttle[1], John Elliott[1], Geneva Chong[2], Juli Fahy[3], Karen Tucker[4], Eric Livo[1], Jim Ferguson[5], Dennis Murphy[4], Allen Merewether[6] and Amanda Clements[4]

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Poster

Key words: Collaboration, Integrated Research, Soil Stability, Erosion

Research on the Mancos Shale landscape of the Gunnison Gorge National Conservation Area (GGNCA) in western Colorado brought together researchers and managers from the USGS, BLM, and BOR. This poster presents an overview of the project and highlights some of the results of this multidisciplinary effort. Topics addressed include (a) hillslope erosion, (b) geochemical aspects of pedogenesis, (c) mapping of soil-surfaces using remote-sensing, and (d) interrelationships among plant populations, soil-crust communities, geomorphology, soil chemistry, and geology. Results include (a) Background hillslope erosion rates in the GGNCA are highly variable. Off-highway vehicle disturbance both increases and decreases runoff and sediment yield, but the greatest adverse effects occur on east and west hillslope aspects. (b) Presence of the endangered species, *Eriogonum pelinophilum* correlates with relatively constant mean SAR values (sodium adsorption ratio) in soil profiles between the surface and a depth of 45 cm. In control plots without *Eriogonum pelinophilum* mean SAR values increase by a factor of 10 with depth. (c) Surface soil aggregate stability, measured with the slake test, are most correlated with visible biological soil crusts. Non-visible biological soil crust organisms as indicated by chlorophyll a are present on soils that appear bare. Management that minimizes soil disturbance could result in increased soil stability and decreased erosion. (d) Data suggest that in 2005, about 4% of the annual salt load (280,000 t) and less than 1% of the annual Se load (4,600 kg) in the Uncompahgre River (an upper Colorado River tributary) was derived from soil on the GGNCA.

Mancos Shale Landscapes II: Science and Management of Black Shale Terrains - Gunnison Gorge Conservation Area

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Oral Presentation
Key words: Collaboration, Integrated Research, Land Use, Soil

Regions underlain by black shale, especially in arid/semi-arid areas, pose significant problems for land-use managers. In many areas insufficient data exist for resource and land managers to formulate scientifically supportable decisions for the stewardship of the landscapes. In general, the major geologic and biologic processes responsible for the evolution of the landscapes and their associated resources are understood. However, there is a lack of detailed understanding that is required to quantify the significant processes or to create predictive models that can accurately account for changes in land use (especially, off-highway-vehicles), climate, and National resource need, among others.

Mancos Shale landscapes of the western United States have become a focal point for the need to develop science information to support sound land management decisions and policies. This need has arisen primarily because of (1) increased and changing demands for land use, and (2) issues (such as salt, selenium and sediment loading; and soil, vegetation and habitat disturbance) related to the health of the upper Colorado River.

This project brought together researchers and managers from the USGS, BLM, and BOR to define and begin investigating the most critical management issues and science gaps. Work was focused on the Gunnison Gorge National Conservation Area in western Colorado but was linked to other Mancos landscape study sites in Colorado and Utah. This presentation will offer an overview of the project; topics touched on include (a) erosion of Mancos Shale and the impacts of various types of land use; (b) geochemical aspects of pedogenesis of the Mancos Shale; (c) development of remote-sensing, soil-surface, mapping techniques; (d) examination of the interrelationships among plant populations, vascular and biological soil-crust communities, geomorphology, soil chemistry, and geology; and (e) development of effective information transfer and visualization methodologies that facilitate the integration of science and management.

World's Longest Speleothem: New Results from Radiometric Dating and Hydrologic Observations

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Oral Presentation
Key words: Climate Change, Water Chemistry, Fort Stanton-Snowy River National Conservation Area

The Snowy River formation, a stream-pool deposit located in a recently discovered passage in Fort Stanton Cave, New Mexico, may be the world's longest continuous cave deposit. The formation is composed of pure white calcite that coats silt and mud deposits on the floor of the cave passage, and currently extends from north to south for >7 km with its southern terminus still undefined. Core samples collected from the Snowy River deposit reveal a laminated internal structure, indicating episodic deposition of sub-millimeter scale calcite laminae during periods when the passage stream is activated. The age of the basal layer has been determined by U-Th dating to be only

850 ± 200 years old, suggesting an abrupt change in climatic or hydrochemical conditions within the past millennium. Since its discovery, the Snowy River passage has experienced two documented periods of streamflow in 2007 and 2008. During each episode, a thin layer of new calcite was deposited. The source of water in the passage is unknown. Water level data loggers indicate an abrupt (~1 week) disappearance of floodwaters in December, 2008 for the most recent episode of stream activation, suggesting a point source of recharge to the cave system such as a sinkhole, losing stream or subterranean pool. Initial precipitation of the Snowy River deposit may correlate to a transition from perrenial streamflow in the cave to ephemeral conditions ~800 years ago due to changes in either climatic conditions, stream water chemistry, or source water input.

Concretions in Sandstones Provide Clues to Landscape Development during Uplift of the Colorado Plateau

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Oral Presentation
Key words: Navajo Sandstone, Concretions, Jurassic Deposition, Grand Staircase-Escalante National Monument, Ancestral Escalante River

Pipe-like concretions are common within outcrops of the Navajo Sandstone exposed in the deep canyons of Grand Staircase-Escalante National Monument in south-central Utah. Concretions form within buried sediments and sedimentary rocks via highly localized cementation by minerals like calcite, siderite, and pyrite. They can take on many shapes, but, if precipitated by moving groundwater, they commonly assume a near-horizontal, pipe-like form. We measured the orientation of 163 pipes in the Navajo that are associated with rock fractures and, over a broad area stretching from the edge of the Aquarius Plateau to the Colorado River, lie nearly perfectly parallel to one another. These concretions are oriented NW-SE. Our work indicates that although most other features within the Navajo developed during or soon after Early Jurassic deposition (200 million years ago), the pipe-like concretions formed much more recently, perhaps within the last 2 million years.

On the Great Plains of eastern Wyoming and western Nebraska, pipe-like concretions are common within sandstones of the Arikaree Group (Miocene). Those concretions are also nearly horizontal and are oriented E-W, parallel to the flow direction of both surface water and groundwater of the region. Apparently, Arikaree sandstones were cemented by the shallow groundwater moving beneath east-moving Plains streams. The consistent NW-SE orientation of the Navajo concretions indicates a similar origin. A few million years ago, the ancestral Escalante already was draining the southeast slopes of the Aquarius Plateau, but it had not yet cut canyons into the Navajo Sandstone. Groundwater flowing beneath the riverbed also moved southeastward and formed the concretions. As the Colorado Plateau is uplifted and rivers cut deep canyons, concretions are being exposed on canyon walls. That the rivers and concretions lie parallel is no coincidence.

Microbial Communities of Fort Stanton Cave, New Mexico: Clues to Geological Processes and Human Impact

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Oral Presentation

Key words: Microorganisms, Caves, Geomicrobiology, Human Impact, Fort Stanton-Snowy River National Conservation Area

Fort Stanton Cave, which has recently been designated as Fort Stanton-Snowy River National Conservation Area contains a recently discovered, phenomenal cave formation, an almost eight kilometer long river made of calcium carbonate, called Snowy River. The walls and ceiling above this formation are coated with a black manganese oxide crust, which is inhabited by a complex community of microorganisms. To understand both the manganese crusts and the Snowy River formation, and to monitor the impact of humans on the microbial communities inhabiting these sites, we have undertaken studies using molecular biology and traditional microbiological techniques. Samples of the manganese oxides were taken for DNA analysis, in which the DNA was extracted, the 16S rRNA gene was amplified, cleaned and sequenced, and a phylogenetic analysis was conducted. This analysis showed the presence of 12 phyla of bacteria, including *Proteobacteria, Gemmatimonadetes, Bacteroidetes, Acidobacteria, Chloroflexi, Firmicutes, OP10, Verrucomicrobia, Cyanobacteria, Planctomycetes,* and *Nitrospira.* Many novel organisms were detected within these communities. To ascertain whether bacteria were present on Snowy River that could precipitate calcium carbonate, samples of the Snowy River calcium carbonate flowerets were inoculated into R2A medium, subcultured, and then transferred to Boquet's medium to test for carbonate precipitation. Three culture isolates were shown to produce calcium carbonate; sequencing revealed that these isolates belong to the genus *Bacillus*, which has been shown to produce calcium carbonate in other caves studies. Finally, high and low impact areas, based on records of human visitation, were sampled to test for the presence of *Staphylococcus aureus*, *E. coli*, and fungi, examples of human indicator bacteria. Tests showed that *Staphylococcus aureus* is the best indicator of human impact. These results will help inform management decisions concerning Fort Stanton and the very fragile Snowy River, and are revealing a novel and complex microbial communities.

Mineralogical Studies in Snowy River Passage, Fort Stanton Cave, New Mexico

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Poster
Key words: Caves, Calcite, Manganese Oxide, Minerals, Fort Stanton-Snowy River National Conservation Area

Fort Stanton Cave, New Mexico hosts an important new discovery: the Snowy River passage. This unusual passage has been explored to over 7.5 km with no end in sight. The walls and ceilings of Snowy River are coated with jet-black manganese oxide, and a white calcite "river" is present on the floor of the passage. This Snowy River formation is a thinly laminated carbonate crust that extends more or less continuously along the entire length of the passageway. The calcite formation consists of thin laminae that vary from microns to millimeters in thickness and appear to be continuous across drill cores taken several km apart. The minor element chemistry, determined by microprobe traverses across one core, varies significantly from layer to layer. The erratic chemistry and changes in thickness of the lamellae suggest that episodic flooding events of variable duration have deposited the Snowy River formation, with new calcite precipitated with each flooding event over a period of about 820 (+/-200) years.

Black Mn-oxides on the walls of the passage coat centimeter-thick clay and silt that was deposited on the limestone bedrock prior to the deposition of the white Snowy River calcite. The layers in the wall and floor sediments suggest episodic deposition during an earlier era when the passage was apparently open to the surface. The manganese oxide coating consists of a very dark but thin layer of manganese minerals, which in cross-section, is composed of discontinuous dendritic clusters or laminated structures. A relict manganese layer is often present a millimeter under the surface, also suggesting multiple depositional periods of the manganese oxide coating.

Understanding the mineralogical composition of the manganese coatings and the Snowy River calcite formation will help to provide a comprehensive interpretation of the geochemical, hydrological, and microbiological history of the cave.

Paleontology

Fossil Discoveries and Potential of Some Colorado BLM NLCS Areas

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Oral Presentation
Key Words: Fossils, Non-renewable Resources, Discovery

Paleontological resources have been identified in several National Landscape Conservation System (NLCS) areas in Colorado. Colorado NLCS areas presently known for fossils include one National Monument (Canyon of the Ancients National Monument), three National Conservation Areas (Gunnison Gorge National Conservation Area, McInnis Canyons National Conservation Area, and Dominguez-Escalante National Conservation Area), two of the five Wilderness Areas (Black Ridge Canyons Wilderness Area and Gunnison Gorge Wilderness Area), and four of the 54 Wilderness Study Areas (Dolores River Canyon, Powderhorn, Sewemup Mesa, and Skull Creek). Sedimentary rocks from these areas have produced Mesozoic vertebrates and plant, invertebrate, and trace fossils from the Triassic, Jurassic, and Cretaceous periods. Some of the original dinosaur finds date to as early as 1900. Based on

this history, many of Colorado's NLCS units will continue to yield new paleontological finds of national and international scientific merit. Ongoing research in several of these NLCS areas has been producing new fossils. Likelihood of discovering more paleontological resources continues into the future, based on management actions, reports from the public, and active research. Known fossils should be collected, studied, or monitored as scheduled and managed to ensure preservation of these scientific resources. NLCS designations in several cases have changed how these resources are managed, with more possibilities for yielding future scientific information on past NLCS ecosystems and their inhabitants.

High-Tech Digital Photography of World-Class Fossil Footprints: Photogrammetric, Ichnological Documentation of the Prehistoric Trackways National Monument, New Mexico

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Oral Presentation
Key words: Paleontology, Ichnology, Close-Range Photogrammetry, New Mexico, Permian

A newly established (2009) NLCS unit in the Robledo Mountains of southern New Mexico allows for a unique opportunity to use state-of-the-art photographic documentation technology to conserve, protect, and enhance exceptionally and nationally important paleontological resources. The Prehistoric Trackways National Monument (PTNM) consists of approximately 5,280 acres (21.37 sq km) of BLM managed land in Doña Ana County north of Las Cruces, New Mexico. PTNM is one of the world's most important footprint localities, as it contains some of the best examples of Paleozoic tracks in North America and is one of the most scientifically significant Early Permian tracksites known. Fossilized traces of vertebrates (amphibians and reptiles) and invertebrates (arthropods), as well as fossilized plant impressions and petrified wood are preserved in the red beds of the Robledo Mountain Formation of the Hueco Group. Deposition occurred on tidal flats of the northwestern shore of a marine embayment, approximately 280 million years ago (Late Wolfcampian). Due to the high occurrence, ichnotaxonomic diversity, and morphological preservational variations, the tracks at the PTNM provide an unprecedented glimpse into paleoecology of the Permian Period and will provide valuable information into the understanding of Paleozoic ichnotaxa worldwide. The designation of the Monument protects this unique fossil resource and provides an opportunity for scientific study, public interpretation, and recreation. This unique biotic assemblage warrants the high level of documentation provided by close-range photogrammetry. In 2010, selected tracks and trackways were documented using close-range photogrammetric techniques. Three-dimensional image datasets created from this digital photography provide a permanent digital record of the tracks and is a non-destructive method to obtain 3D data for assessment. The digital virtual representations provide an effective tool for presenting this unique site to members of the general public, land managers, and the scientific community, thereby increasing the awareness and concern for such natural treasures.

Fossil Tracks and Future Science: Paleontological Resources in the Vermilion Cliffs National Monument and Paria Canyon-Vermilion Cliffs Wilderness

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Oral Presentation
Key words: Paleontology, Ichnology, Close-Range Photogrammetry, Utah, Arizona, Early Jurassic, Vermilion Cliffs National Monument, Paria Canyon-Vermilion Cliffs Wilderness

The Vermilion Cliffs National Monument and the Paria Canyon-Vermilion Cliffs Wilderness encompass nearly 400,000 acres of land managed by the BLM in Coconino County, Arizona and Kane County, Utah. In Early Jurassic times (~190 million years ago), a vast (~350,000 sq.km) desert covered this area. This erg (sand sea) may have reached thicknesses in excess of 700 m. These sands lithified into what is now called the Navajo Sandstone. Today, people from around the world come to this area to see the spectacular, brightly colored rock formations, such as the thin, swirling sandstone strata of the erosional feature called the ”Wave” in the Coyote Butte North area of the Monument. Although known for its striking and picturesque geology, little is understood of the unique paleontological resources within these NLCS units. Notably, this area contains an interesting ichnodiversity with important preservational features. Different track types have been observed, including tridactyl (*Grallator*) and tetradactyl (*Batrachopus* and *Navahopus*) forms, as well as unusual invertebrate traces. Although the discovery of fossil tracks is on the rise worldwide, the general understanding of the complexities of vertebrate ichnology and significance of trace fossils remains remarkably low. Unfortunately, ichnological ignorance has led to misinformation and mismanagement, resulting in dangerous and difficult situations for scientists, land managers, and the public. Photogrammetric documentation incorporated with Geographic Information Systems (GIS) can assist in the proper location, documentation, preservation, and management of these sites for current and future generations. Three-dimensional image datasets created from digital photography can provide a permanent digital record of fossil tracks and is a non-destructive method to obtain 3D data for assessment. In addition, misinformation, misinterpretations, and miscalculations can be more readily corrected. As a result, valuable insights and interpretations can be made from these data, providing an ideal opportunity for the successful synergy of management, science, technology, interpretation, and recreation within NLCS units.

Contributions by the General Public to the Management of NLCS Paleontological Resources

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Poster
Key words: Paleontological Resources, General Public, Partnerships, Citizen Science, Discovery

Important paleontological discoveries can be made by members of public. An interested and well informed public is a powerful force in the management of paleontological resources within the NLCS. Examples from New Mexico are presented.

In 1979, while hiking in what would become the Ojito Wilderness Study Area (WSA) and later Wilderness Area (WA), two hikers discovered a series of large vertebra eroding out of a sandstone bench and reported it to the New

Mexico Museum of Natural History and Science (NMMNHS). This discovery prompted an excavation by the NMMNHS. Preparation of the specimen collected included over 1000 volunteer hours. Seismosaurus is now replicated in a cast and on display.

In 1985, an avocational paleontologist and geology student at New Mexico State University (NMSU) brought the attention of the scientific community to what is now the Prehistoric Trackways National Monument. This individual's effort with community support was instrumental in establishing the PTNM in 2009.

In 1996, an avocational paleontologist and NMMNHS volunteer discovered portions of a large theropod eroding out of the badlands exposed in the Bisti/De-Na-Zin Wilderness Area (BDNZ). Documenting the find with photos and map points, allowed for museum staff and BLM to conduct an excavation inside the wilderness. The "Bisti Beast" is now on display at NMMNHS.

In 2004, a visitor to the BDNZ WA documented four vertebrate fossil localities using a newly purchased GPS. The Ohio visitor reported these localities to the NMMNHS and a follow up trip relocated the localities. Specimens were recovered and conserved in the collections. Students and museum volunteers were part of the recovery team.

Educational brochures for the general public providing general guidance for "what to do" when locating paleontological resources and partnering with available institutions will enhance BLM's capability to accomplish reconnaissance survey, monitoring and collection of important paleontological resources.

New Mexico's Oldest to Newest NLCS Paleo Units: Developing Effective Science Strategies

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Oral Presentation
Key words: Fossils/Management, Bisti/De-Na-Zin Wilderness Area, Fossil Forest Research Natural Area

Within the NLCS, some units are known for preserving a rich history of life on earth. Two such units in New Mexico are areas that reveal the complexities of ancient environments and through fossil collection, geologic study and collection of scientific data, biological turnover, paleoclimate and ancient paleoecosystems can be unraveled. Developing appropriate science strategies for these units is critical to effective management.

New Mexico's oldest NLCS units were established in 1984 with passage of the San Juan Basin Wilderness Act, creating the Bisti/De-Na-Zin Wilderness Area (BDNZWA) and the Fossil Forest Research Natural Area (FFRNA). In 1996, the wilderness areas were linked, expanding to 45,000 contiguous acres. FFRNA and BDNZWA contain the late Cretaceous Kirtland-Fruitland Formations and Paleocene Nacimento Formation and have produced fossil material since the 1870's. This fauna documents biological turnover and high erosion rates expose fossil material which rapidly degrades after exposure. Although collection and research of fossil material continues, the last systematic inventory was conducted in 1977. In addition to a systematic approach to surface collection and assessment of fossils, integrated studies that incorporate pollen, isotopic dating, magnetic and stratigraphic studies provide data to reconstruct paleoecosystems and should be identified as a science priorities.

The Prehistoric Trackways National Monument (PTNM)(2009), established to conserve, protect, and enhance the unique and nationally important paleontological, scientific, educational, scenic, and recreational resources values, is New Mexico's newest Paleo NLCS unit. PTNM includes a megatrackway consisting of extensive outcrop of Permian terrigenous red beds sandwiched between marine limestones. These layers contain footprints of numerous amphibians, reptiles, insects and invertebrates, plant impressions and petrified wood. An initiative to consolidate known data, re-document known localities in current GPS standards and conduct additional inventory has begun. This consolidation of existing data with addition of new inventory will provide planning data and assist in development of a science strategy.

Boots on the Ground—The Benefits of Paleontological Reconnaissance in Wilderness Areas

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Oral Presentation
Key words: Paleontology, San Juan Basin, Reconnaissance, Wilderness, Research

The San Juan Basin of New Mexico has been recognized as containing significant paleontological resources since the 1870s. The BLM Farmington Field Office manages 165,204 acres of specially-designated paleontologically significant lands, of which 44,897 acres fall into the Bisti/De-Na-Zin Wilderness Area and Ah-shi-sle-pah Wilderness Study Area.

Collection and removal of paleontological resources from such areas is sometimes considered to be incompatible with the concept of wilderness preservation. In truth, professional researchers play an important role in assisting the BLM to protect and preserve scientific resources and the very wilderness itself. They provide the BLM with additional "boots on the ground," increasing the available manpower for monitoring the condition of paleontological resources exponentially. They serve as extra pairs of eyes to monitor the ongoing erosion of fossil beds, as well as assessing the significance of new exposures. This "paleontological reconnaissance" provides the field office with critical information that is used in the formulation of management strategies in managing these resources for the maximum public benefit.

Professional paleontologists also serve as patrols against illegal collection. They are not the only ones interested in fossil resources, and there is an active and lucrative trade in illicitly-obtained fossils. Without the assistance of professionals in monitoring and evaluating newly-exposed beds, unusual and even unique specimens may be entirely lost to science before their existence is even known. An equally important consideration is that illegal collectors have no interest in or regard for the preservation of the wilderness as such, and that plundering of unmonitored fossil resources may result in more extensive impairment of the wilderness character of the region. By contrast, controlled, permitted, scientific excavations can preserve both the fossil record for research and education, and the wilderness itself.

A New Association of Early Permian Invertebrate Trace and Body Fossils from Prehistoric Trackways National Monument of South-Central New Mexico

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Oral Presentation
Key words: Prehistoric Trackways National Monument, Paleontology, Trace Fossils

The newly established Prehistoric Trackways National Monument near Las Cruces, New Mexico, encompasses scientifically important deposits containing Early Permian vertebrate and invertebrate trace fossils that have received scientific study for more than 15 years. We report a newly discovered trace and body fossil association from the border of the Monument, which occurs stratigraphically high in the Lower Permian Robledo Mountains Formation in a lithofacies exposed by rock quarrying in the Community Pit. This new association consists of numerous hydrozoan (chondrophorine) body fossils, several xiphosuran (horseshoe crab) trace fossils, a large *Taenidium*-like burrow, and an actinarian (anemone) compound trace fossil in association with sparse trackways of arthropods and tetrapods. The chondrophorine specimens are preserved on mud-draped sandstone slabs as positive hyporelief body impressions over an outcrop area of tens of meters and likely record a mass stranding. Several medusae and hydroids show exceptionally preserved subumbrella anatomy. These are the first chondrophorine fossils known from the Permian. Multiple xiphosuran burrowing traces preserved in positive hyporelief are readily assignable to *Selenichnites rossendalensis*. This is the first record of *S. rossendalensis* from the Permian. An unusual actinarian compound trace shows a relatively large dwelling structure (domichnia) combined with tentacular resting impressions (cubichnia) on the upper portion. Assignment is kept open pending further study, although it likely represents a new ichnotaxon. The *Taenidium*-like burrow is unusually large compared to other examples of meniscate burrows from the Robledo Mountains Formation.

This new body and trace fossil association occurs in a siliclastic facies paralic to the Hueco seaway. It represents a different facies, one that was more marginally marine, than the inland tidal flat facies that has previously been reported from the Lower Permian of the Prehistoric Trackways National Monument.

Scientific Significance of Early Permian Trace Fossils, Prehistoric Trackways National Monument, New Mexico

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Oral Presentation
Key words: Science, Paleontology, Early Permian

The Prehistoric Trackways National Monument encompasses ~ 5300 acres in the Robledo Mountains, a horst block along the western margin of the southern Rio Grande rift that exposes a 500-m-thick section of upper Paleozoic, carbonate-dominated strata. Near the top of this section, the Robledo Mountains Formation of the Hueco Group contains extensive trace fossil (ichnofossil) assemblages made by invertebrates and vertebrates that lived on tidal flats of the Early Permian Hueco seaway. Discovered in the 1980s, nearly two decades of scientific research have identified the Robledo trace fossils as one of the most scientifically significant ichnofossil records known, a true trace-fossil Lagerstätte. This significance derives from documentation by Robledo traces of the: (1) presence of many organisms, especially arthropods, not known from coeval strata in New Mexico; (2) new ichnotaxa, not previously known from the ichnofossil record; (3) complex apterygote insect behaviors, including some of the oldest records of jumping; (4) diversity, inferred trophic dynamics and paleoecology of the Early Permian tidal flat biota; (5) extramorphological variation in tetrapod footprint morphologies, allowing comprehensive

ichnotaxonomic revisions; and (6) composition of ichnofossil assemblages, ichnocoenoses and ichnofacies that are a pivotal part of modeling spatial variation in Early Permian red-bed terrestrial communities. The degree of scientific study of the Robledo ichnofossils is reflected by two volumes of collected scientific articles, one monograph, dozens of articles in scientific journals and numerous abstracts of presentations at scientific meetings. Despite intensive collecting and study, much new information about Robledo ichnofossils continues to be discovered. Recent discoveries include the identification of a new assemblage that preserves limulid and anemone traces together with chondrophorine body impressions, and demonstrate that ongoing research and collecting of the Robledo ichnofossils will continue to advance our understanding of the Early Permian tidal flat communities documented by ichnofossils in the Prehistoric Trackways National Monument.

The History of Prehistoric Trackways National Monument: Evolution of the Discovery and Recognition of a World Famous Fossil Deposit

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Oral Presentation
Key words: Prehistoric Trackways National Monument, Paleontology, Trace Fossils, Sociology of Discovery, Lagerstätte

The Robledo Mountains of southern New Mexico contain one of the world's richest fossil footprint localities. This fossil deposit, located on BLM managed land, has increased in global significance since one of Jerry P. MacDonald (JPM) made the initial discoveries of large *in situ* trackways in 1987. Continued exploration by JPM over the next 23 years has resulted in the discovery of more than 100 additional fossiliferous exposures of importance that in total represent one of the most complete Paleozoic *Lagerstätten* known on earth. The paleontological discoveries, which have occurred in the Robledo Mountains, can be separated into five distinct phases: The extent and significance of vertebrate fossil footprint occurrences and their significance in a global context; the discovery of numerous outcrops containing globally unique invertebrate trace fossils (i.e., walking and hopping/landing traces of insects and other arthropods); the discovery of a diverse and globally unique trace fossil assemblage within the Robledo Mountains Community Pit (i.e., proto-jellyfish, vertebrate swimming traces and invertebrate burrows); the discovery of extensive deposits of petrified wood, which include numerous intact logs; and finally the very recent discovery of an extensive and heretofore unknown deposit containing a diverse fossil leaf flora found in association with petrified logs. Each of these phases has resulted in heightened political and scientific activity. Here, we will follow the slowly evolving history of fossil discovery in the Robledo Mountains, and the roles scientists and government agencies have played in its development. The Robledo Mountains fossil deposit provides a unique look into the entire process of discovery, from the initial finds to the subsequent declaration in 2009 of the area as a national monument.

Tracking Technological Advancement: Close-Range Photogrammetry at the Twentymile Wash Dinosaur Tracksite, Then and Now

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Oral Presentation
Key words: Resource Inventory, Resource Monitoring, Close-Range Photogrammetry, Dinosaur Tracks

Located approximately 25 kilometers southeast of the town of Escalante, Utah, the Twentymile Wash Dinosaur Tracksite (TWDT) was discovered during a 1998 paleontological survey on the Grand Staircase-Escalante National Monument. At this locality hundreds of Middle Jurassic dinosaur tracks are exposed at the top of a 400-meter-long east/west trending bench of the Entrada Sandstone. Since the time of its discovery, TWDT has been intensively studied and visited. The primary documenting and mapping of the site were conducted through the use of close-range photogrammetry (CRP). Low-level imagery of the main track-bearing surface was captured in 2001 using a helium-filled blimp. At that time, current technology necessitated the use of an expensive metric camera to capture images at precise spacings and orientations. Processing of those images was carried out by trained photogrammetric professionals, utilizing specialized computer hardware and software. When first reported, the census of tracks was approximately 300. After photogrammetric mapping, over 1000 tracks were identified and accurately located in 3D space. Not only did these efforts increase the knowledge of the unique, paleontological resources at TWDT, but they also provide a visual and quantifiable baseline that may be used to evaluate and better understand changes that occur to the track surface. During the past ten years, close-range photogrammetry has experienced a rapid technological evolution. Economic, high-resolution, digital cameras, increasing capabilities of computers, and advancements in the analytical software have simultaneously decreased the costs and increased the usability of CRP. Currently, accessible tools and knowledge for taking CRP images allow field resource specialists to take the needed photogrammetric images to effectively and accurately document and monitor a wide variety of resources. In addition to ground-based photography, low-level aerial imagery (taken from small aircraft or unmanned vehicles) can be used for regional assessments and scientific studies in specific NLCS units.

Tracking Dinosaurs Through the Middle Jurassic Dunes: An overview of the Twenty mile Track Site, Grand Staircase-Escalante National Monument, UT

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Oral Presentation
Key words: Paleontology, Dinosaur Tracks, Ichnology, Geographic Information Systems (GIS), Close-Range Photogrammetry

The BLM National Landscape Conservation System is home to a wealth of significant geological and paleontological resources. One such resource is the Twentymile Wash Dinosaur Tracksite (TWDT) located within Utah's Grand Staircase-Escalante National Monument. Here over one thousand dinosaur tracks are exposed at multiple horizons along the upper portion of a sloping sandstone bench. The tracks are preserved as darker sediment infillings and as alternating light and dark underprinted sand laminations in the " Escalante Member" of the Middle Jurassic Entrada Sandstone. The tracks exhibit significant morphological variation, which are, in part, the result of exposure of underprints at depth. Within a single trackway, morphology can vary in as few as three steps from distinct tridactyl footprints (with evidence of digital pads and claw impressions) to oval concentric circles

representing deep underprints. In addition, morphological variations may be the result of slope gradients that existed at the time of track formation and through soft sediment deformation. GIS analysis of trackway geometry (including foot length and width ratios, pace angulations, stride lengths, and straddle widths) were conducted. These calculations provide further insight into the ichnites of the trackmaker. By examining the spatial context of these footprints, both to each other and within the chronology and spatial context of the site, a greater understanding may be gained into the expression of deep underprints and their usefulness in tracksite analysis, as well as the true taxonomic diversity of the site. Through these studies better understanding can be gained of the paleobehavioral responses exhibited by populations of theropod dinosaurs living in fluctuating environments. At TWDT these responses can be traced over time through several stratigraphic horizons. Behavioral responses, such as seasonal migrations, feeding, or faunal variations through time, might reflect ecosystem changes occurring on a broader scale in the terrestrial systems of the Middle Jurassic.

Minimum Tool: A Blackhawk Helicopter? Excavation and Retrieval of the "Bisti Beast"

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Poster
Key words: Paleontology, Wilderness, Excavation, Minimum Tool

In 1998 the partial skull of a new genus and species of *Tyrannosauroid*, nicknamed the "Bisti Beast," was discovered during routine paleontological reconnaissance in the Bisti/De-Na-Zin Wilderness in northwestern New Mexico. Its excavation presented unique challenges due to its occurrence in a designated Wilderness Area. This was the first paleontological excavation authorized in a wilderness by the New Mexico BLM, and employed the "minimum tool" principle. The San Juan Basin has been recognized since the late 1800s as containing significant vertebrate paleontological resources, many of which are found in the 44,897 acres of the Bisti/De-Na-Zin Wilderness and the Ah-Shi-Shle-Pah Wilderness Study Areas, and the "Beast" provided an important test case.

The Wilderness Act requires that no mechanized transport (including wheeled carts) nor mechanical equipment be used. Additionally, the landing of aircraft is prohibited. The highly-erosive nature of the sediments and the fragility of the vegetation prohibited camping on-site, and the presence of a nesting ferruginous hawk nest added further complications.

Biophysical impacts to the wilderness were limited by hand excavation, and all materials were packed in and out on foot. Overnight camps were established outside the wilderness boundary. The most dramatic instance of the use of the "minimum tool" principle involved the removal of the jacketed skull via a hoist attached to a Blackhawk helicopter. This "minimum," though not "primitive" method was considered to effectively meet the criteria for a "minimum tool," as it best preserved the physical integrity of the site. Although the presence of a military helicopter hovering over the wilderness for a day may have had temporary impacts on the sense of solitude, the more important consideration is the longer-term impacts on the ephemeral, intangible sense of "wildness" that pervades the Bisti/De-Na-Zin. Post-excavation analyses of the locale indicate that this elusive quality has been preserved.

The Jerry MacDonald Paleozoic Trackways Collection from Prehistoric Trackways National Monument, Robledo Mountains, Southern New Mexico

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Oral Presentation
Key words: Prehistoric Trackways National Monument, Paleontology, Trace Fossils

The Robledo Mountains, Doña Ana County, in southern New Mexico have yielded thousands of Permian (Wolfcampian) tracks and traces since their discovery in the 1980s. This collection, initiated by Jerry MacDonald, is now housed at the New Mexico Museum of Natural History and Science, Albuquerque. It preserves over a thousand cataloged specimens, from 14 localities, ranging in preservation from single tracks to trackways composed of dozens of individual footfalls. The breadth of ichnotaxa preserved is extensive including both vertebrates (*Batrachichnus salamandroides*, *Limnopus* isp., *Hyloidichnus bifurcatus*, *Dromopus agilis*, *Gilmoreichnus hermitanus*, *Dimetropus nicolasi* and *D. leisnerianus*) and invertebrates (*Augerinoichnus helicoidalis*, *Cochlichnus anguineus*, *Dendroidichnites irregulare*, *Diplichnites* isp., *Diplopodichnus biformis*, *Kouphichnium*?, *Lithographus hieroglyphicus*, cf. *Lockeia*, *Octopodichnus* cf. *O. didactylus*, *Palmichnium macdonaldi* [holotype], *P. palmatum*, *P. pottsae*, *Rotterodichnium major*, *Selenichnites belosis* [holotype], cf. *Spirorhaphe azteca*, *Stiallia pilosa*, *Stiaria intermedia*, *Striatichnium biflabellis*, *Tonganoxichnus apacheensis*, *T. buildexensis*, *T. robledoensis* [holotype], *Treptichnus bifurcus*, *Serpentichnus sigmoidalis* [holotype] and taxa described in open nomenclature. Publications on the trackways include various newspaper and other periodical articles, a popular book (*Earth's First Steps: Tracking Life before the Dinosaurs* by Jerry MacDonald) and three major research works: *Early Permian Footprints and Facies*, a 1995 edited volume; *Permian Stratigraphy and Paleontology of the Robledo Mountains, New Mexico*, a 1998 edited volume; and *Ichnology of an Early Permian Intertidal Flat*: *The Robledo Mountains Formation of southern New Mexico*, a recent monograph by Minter and Braddy. The extensive collecting and high profile research have led to the designation of the Prehistoric Trackways National Monument in the Robledo Mountains and stimulated a renewed research interest in the area and its trace fossils.

A Century of Dinosaur Collecting in the San Juan Basin, New Mexico: Historically and Paleontologically Important Discoveries from NLCS Lands of Ah-Shi-Sle-Pah WSA, Bisti/De-Na-Zin Wilderness, and the Fossil Forest Research Natural Area

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Oral Presentation
Key words: Sinosaurs, Hologypes, San Juan Basin, Upper Cretaceous

In 1910 Barnum Brown, from the American Museum of Natural History, reported on dinosaur remains from the San Juan Basin, collected by him in 1904, including the holotype of *Kritosaurus navajovius*, a hadrosaurid from the so-called "Ojo Alamo beds," now considered, in part, to be the De-na-zin Member of the Kirtland Formation. Charles W. Gilmore (United State National Museum, Smithsonian) described a number of turtles and dinosaurs from the San Juan Basin in a series of papers published between 1916 and 1935. Among the most notable dinosaurs was the large titanosaurid sauropod *Alamosaurus sanjuanensis*, known from the Ojo Alamo Formation (=Sandstone) and based solely on a scapula (holotype) and ischium (paratype). In the 1920s, the venerable field

paleontologist Charles H. Sternberg collected the holotypes of the ceratopsid dinosaur *Pentaceratops sternbergii*, described by Osborn in 1921, *Parasaurolophus tubicen*, described by Wiman in 1931, and *Parasaurolophus crytocristatus*, described by Ostrom in 1961. Written off as being a relatively unproductive region by Gilmore in 1930, the dinosaur-bearing rocks of the San Juan Basin, New Mexico, did not receive much attention between 1930 and 1977.

In 1977, interest in the fossil resources of the San Juan Basin, NM, was reignited as the result of pending coal and mineral extraction in the Bisti-Star Lake region. An eight-month long reconnaissance of the area resulted in a report to the BLM, by Kues and others, assessing the paleontological importance of the Bisti-Star Lake area and mitigation plan for this region. The report set in motion the establishment of wilderness and wilderness study areas to protect the paleontological specimens of these places. These areas include the present-day Bisti/De-na-zin Wilderness, Ah-shi-sle-pah Wilderness Study Area and the Fossil Forest Research Natural Area.

Renewed interest in the dinosaur fields of the San Juan Basin, by the State Museum of Pennsylvania and the New Mexico Museum of Natural History and Science, began in 1995 and continues to this day. Additional world-class specimens have been discovered including the most complete skull of *Parasaurolophus tubicen* in 1995, the holotype of a new ankylosaurid, *Nodocephalosaurus kirtlandensis* in 1996, the holotype of a new pachycephalosaurid, *Prenocephale* (=Sphaerotholus) *goodwini* in 1998, and the holotype of a new ceratopsid, *Ojoceratops fowleri* in 2010, which are among the more notable new dinosaurs from this area. Other new taxa are also being named and described including a new genus and species of caenagnathid theropod and a new genus and species of pterosaur, New Mexico's first pterosaur. The Upper Cretaceous rocks that contain these dinosaurs, and other fossil vertebrates, represent intervals in time that are largely unknown and unrepresented elsewhere in the world. Thus, their unique temporal position and their unique dinosaur faunas make these lands of the utmost scientific importance. The history of collecting, by paleontologists who are considered giants in the field (Brown, Sternberg, Gilmore), add to the importance of these regions, which are part of the National Landscape Conservation System.

The Rise of the Kaiparowits Basin as a Global Scientific Resource

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Oral Presentation
Key words: Paleontology, Stratigraphy, Late Cretaceous, Kaiparowits Plateau, Grand Staircase-Escalante National Monument

By 2000 and after fifteen years of published significant research on the evolution of its mammals, the nearly 8,000 vertical feet of the Kaiparowits Basin's Late Cretaceous geologic section remained a relative *terra obscura* to the global scientific community. This status resulted largely from lack of detailed taxonomic data for most non-mammalian fossil groups. Dinosaurs, which command so much attention from both the public and researchers, had only two taxa identified to species level. Lack of precise age data for many key fossil bearing horizons also detracted from their significance because they could not be placed into the necessary context for regional and global comparisons.

Starting in 2000, a comprehensive field-based inventory and research project on Late Cretaceous geology and paleontology of the Kaiparowits Plateau was initiated in support of key Monument Management Plan decisions. BLM support of partner institutions led directly to inventory of approximately 50,000 acres of fossil-rich badlands and the investigation of key aspects of Kaiparowits geology. Results include five Ph.D dissertations, seven M.S. theses, three post-doctoral research projects, dozens of published abstracts and peer-reviewed papers, two international conference field trips, and a Kaiparowits Basin Project tenth anniversary conference in 2009. From this a book will be published in 2011.

To summarize this recently accumulated body of knowledge, over twenty species of Kaiparowits Basin dinosaurs are now recognized, all of which are new to science. In addition, the first use of radiometric and paleomagnetic dating techniques provides tight age controls for the section. Other studies have elucidated sediment source areas, paleoclimate, depositional rates, and insights into the very reasons why the Kaiparowits region preserves so much bone in the first place. These findings have quite literally forced the rewriting of our understanding of end Mesozoic diversity and evolution in North America and justifiably caught the scientific community's attention.

Unfettered Science in the Public Service: A Decade of Paleontology Resource Management in Grand Staircase-Escalante National Monument

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Oral Presentation
Key words: Paleontology, Resource Management, Cretaceous, Kaiparowits Plateau

Grand Staircase-Escalante National Monument was established 1996. The Proclamation specifically lists the Monument's paleontology as a globally significant key resource for management and research emphasis. In particular, the Late Cretaceous fossil sequence of the Kaiparowits Plateau region had been recently recognized as one of the most complete terrestrial records for that time period in the world. Because managing a resource of this scope with almost no data is impossible, in 1997 the Monument Planning Team created the position of Monument Paleontologist to collect essential baseline inventory data, establish program/resource management goals and facilitate/conduct research. Supported by several key Management Plan decisions, in 2000 the lead author contacted the Utah Museum of Natural History, the Utah Geological Survey, and the Museum of Northern Arizona who all had pure research histories in the Kaiparowits area. In 2001 a comprehensive field inventory started to collect baseline data for at-risk fossil resources and determine where special management was required.

While such inventories are routine for public lands for compliance (NEPA) purposes, this project was different because it is the only time BLM has had a resource specialist determine the managerial data needs ***and*** actively participate with the partners in a comprehensive scientific synthesis of the Kaiparowits' stratigraphy, geochronology, paleoenvironments, and floral and faunal diversity. This symbiotic collection of management (e.g. location, condition, and public/scientific significance) and scientific data (e.g. taxonomy, stratigraphic position, depositional environments) over the last ten years has simultaneously given a clearer picture of management needs, elevated the position of the Kaiparowits Plateau region in the global scientific community, and created

exciting outreach and interpretive opportunities for everyone involved. Most of the success of this project could not have been realized without an underpinning of unbridled scientific inquiry. It is hoped that other NLCS units may learn from this "experiment."

A Unique 10 Million Year Paleontological Record in the Bisti/De-Na-Zin Wilderness Area

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Oral Presentation
Key words: Paleontology, Cretaceous, Paleocene

The Bisti/De-na-zin Wilderness Area (BDNZ) contains scenic badlands that expose a stratigraphic succession that spans much of the Upper Cretaceous (upper Campanian) through the lower Paleocene (Danian). This interval is marked by tremendous changes in terrestrial floras and faunas including a major mass extinction at the Cretaceous – Paleogene (K-T boundary). The BDNZ is richly fossiliferous and is one of the few locales preserving a nearly unbroken paleontological record of this interval.

The upper Campanian Fruitland and lower Kirtland formations represent alluvial-coastal and delta plain environments deposited near the western shore of the Late Cretaceous (late Campanian) Western Interior Seaway. The BDNZ has yielded an impressive diversity of vertebrate fossils, the Hunter Wash local fauna, that includes microvertebrates (including mammals) and articulated dinosaur skeletons from these deposits.

The Naashoibito Member, Kirtland Formation contains a vertebrate fauna, the Alamo Wash local fauna of latest Cretaceous (Maastrichtian) age that is one of the few diverse vertebrate faunas known from this interval outside of the northern Rocky Mountain region. This fauna includes microvertebrates (including mammals) and dinosaurs. Campanian and Maastrichtian floras and faunas of the BDNZ provide evidence crucial to our understanding of diversity leading up to the K-T boundary.

The lower Paleocene Ojo Alamo Sandstone and Nacimiento Formation contain diverse floral and faunal assemblages. They contain important evidence of the ecological recovery and the initiation of the explosive radiation of mammals that followed the K-T boundary. The vertebrate faunas preserved within the BDNZ are especially crucial for examining early Paleocene mammal evolution.

Future research plans in the BDNZ include a collaborative research program that will focus on the Nacimiento Formation strata, flora, and fauna that provide an unequaled record of climate and biotic change through the early Paleocene.

140 Years of Paleontology Research at Sutton Mountain, Wheeler County, Oregon

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Oral Presentation
Key words: Research and Collaboration

Sutton Mountain, a 9x6 mile plateau located in the heart of the John Day basin of central Oregon, has been an area of interest for paleontology research for the past 140 years. Beginning in the late 1860's with the exploration and collections of the frontier minister, Thomas Condon, this location has been visited by every major institution interested in fossil mammals. Researchers such as Cope, Marsh, Sternberg, and Merriam, to name a few, all made collections at this location which represents the entire span of the John Day Formation. The Sutton Mountain area came under the administration of the Bureau of Land Management (BLM) in the late 1980's. It has since become a Wilderness Study Area (WSA) and is currently being considered as one part of a much larger Area of Critical Environmental Concern (ACEC) for paleontology resources in the John Day basin through a resource management plan update. In addition, through an interagency agreement between the BLM and the National Park Service, John Day Fossil Beds National Monument, research continues to occur producing interesting and exciting results.

Biology

Restoration - Botany

The Kane and Two Mile Ranches Program: Advancing the Conservation of Public Lands through Research, Restoration, and Monitoring

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Oral Presentation
Key words: Livestock Grazing, Conservation, Collaboration, Landscape Scale Changes, Paria Canyon-Vermilion Cliffs Wilderness

In 2005, the Grand Canyon Trust and The Conservation Fund jointly purchased the Kane and Two Mile ranches, whose livestock grazing permits extend across 850,000 acres of public lands north of the Grand Canyon, including nearly all of Vermilion Cliffs National Monument (VCNM). The main goal of the Kane and Two Mile Ranches Program is to manage livestock with a conservation emphasis, and work with land management agencies to bolster conservation of the ecological, cultural, and scenic values of this landscape through strong science, active collaboration, and volunteer citizen stewardship. Fundamental to these efforts is an understanding of baseline ecological conditions on the ranches, and their association with natural and human-caused changes to the landscape. To this end, we conducted a first year field- and remote sensing-based ecological assessment of the ranches to assess baseline conditions in soils, ground cover, and vegetation at 606 ground plots, 164 of which are located on VCNM. Results from this effort have been used to identify priorities for site-specific restoration and research projects, and for monitoring landscape-scale changes within the contexts of climate change and livestock grazing. Following the baseline assessment, our work on the VCNM has included mapping of non-native invasive plant species, such as tamarisk and Russian olive; the development of predictive models and maps describing cheatgrass occurrences; and the repeated measures of vegetation at most ground plots. In addition, in 2008 we initiated an ambitious riparian restoration project along a 21-mile stretch of the Paria River. By continuing to work

adaptively and systematically across extensive spatial scales, we intend to develop and implement restoration approaches that are efficient, effective, and relevant to addressing emerging public lands management challenges across the southwestern United States.

Effects of Past Management Treatments on Vegetation Structure

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Oral Presentation

Key words: Vegetation Treatment, Pinyon-juniper Woodland, Biological Soil Crust, Grand Staircase-Escalante National Momument

Pinyon-Juniper (PJ) woodlands are the 3rd largest vegetation type in the US, covering 35.5% of the Colorado Plateau, and are the largest vegetation type administered by the Bureau of Land Management (BLM) on the Colorado Plateau. These woodlands have been increasing in density and spatial extent over the last 100 years. Over the past several decades a variety of PJ removal methods have been employed across large tracts of BLM managed lands in the West in attempts to restore herbaceous productivity to benefit livestock and wildlife. To date, over 700 treatments with varying methods have been applied across ~700,000 acres of PJ woodland on BLM managed lands. In this study, we report on the longer term vegetation and soils response to rangeland improvement treatments conducted by the BLM in time periods ranging from the 1960s to the 1980s in Grand Staircase-Escalante National Monument (GSENM). Twenty five previous treated PJ sites were coupled to nearby untreated controls across GSENM. A variety of plant and soil cover data were collected from these sites in 2006. We observed no differences in tree cover in treated sites relatively to untreated controls. These results suggest that PJ removal methods are relatively ineffective in controlling PJ encroachment over longer time scales. Further, our results do suggest that past treatments have negatively impacted biological soil crust communities, which are critically important in stabilizing soil surface in these aridland ecosystems. These results are particularly relevant to BLM land managers who are currently implementing PJ mechanical treatments across large tracts of land in the West in efforts to better manage fuels in the wildland-urban interface. As a result, a better understanding of the longer term impacts of PJ treatments will better inform future restoration and fuels reduction activities across these landscapes.

Monitoring the Road to Recovery in Headwaters Forest Reserve

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Oral Presentation
Key words: Ecological Restoration, Monitoring, Adaptive Management

The Headwaters Forest Reserve contains a distinct dichotomy of forest and watershed conditions between "pristine" old-growth (3,088 acres) and highly disturbed second-growth forests (4,384 acres) including over 50 miles of abandoned logging roads. Previous land management activities within the Reserve combined with ongoing intensive management surrounding the Reserve have negatively impacted ecological processes and conditions (habitat modification and fragmentation, water quality impairment, invasive weeds, etc.) As set forth in the Resource Management Plan, BLM has implemented a restoration program for the past ten years consisting of road removal, forest thinning, invasive plant control, and reforestation. The RMP also required monitoring, evaluation and adaptive management to "ensure that direction in the authorizing legislation to maintain ecosystem integrity at the Reserve is fulfilled."

This presentation will provide an overview of the attributes we are monitoring, what we are learning and how we are attempting to use that information in an adaptive management context as we travel down the road to recovery in the Reserve. The old-growth forest provides an example of the "destination" but how and when we get there will require rigorous monitoring and adaptive management strategies. After ten short years of restoration and monitoring, the journey has just begun.

Effectiveness Monitoring of Shrub Treatments and Grassland Restoration at the Las Cienegas National Conservation Area (LCNCA)

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Oral Presentation
Key words: Prescribed Fire, Mechanical Treatment, Chemical Treatment, Grassland Monitoring, Mesquite (*Prosopis velutina*), Burroweed (*Isocoma tenuisecta*)

The Las Cienegas National Conservation Area (LCNCA) encompasses 96,300 ac (39,000 ha) of federal and state lands managed by the BLM. Designated by Congress in 2000, LCNCA protects nationally important resources including one of the best remaining native semi-desert grasslands in the borderland region. Over several decades, large portions of these grasslands have been encroached by mesquite and other shrubs compromising grassland integrity and threatening their long-term persistence. In 2007, the BLM began implementing an ambitious plan to reduce shrub cover across 8,500 ha while enhancing native perennial grass and diminishing bare ground cover. Using a suite of mechanical and chemical means, and the reintroduction of fire to this landscape, BLM staff has treated 3,232 ha to date, with some areas subjected to more than one treatment. At permanent transects, TNC, BLM staff, and volunteers have monitored pre- and post-conditions at sites to measure effectiveness of the respective treatments at reducing shrub cover and enhancing indicators of grassland condition. Non-fire treatments have dramatically reduced the cover of mesquite with mechanical grubbing having the most pronounced effect (e.g., 90% reduction), while all treatments have maintained or promoted indicators of grassland health in the year after treatment (e.g., perennial grass basal and litter cover, reductions in bare ground). Effects of burning on mesquite cover have been less pronounced with substantial between-plot variation obscuring potential treatment effects; however, fire has substantially reduced burroweed cover (e.g., 86%). As these sites

are reburned, further effects of fire on mesquite cover may be realized; long-term post-treatment monitoring of these sites will be necessary to bear this out. Widespread reduction of mesquite across this landscape may ultimately improve watershed conditions while simultaneously improving grassland habitat for endemic grassland birds and pronghorn antelope as well as reintroduced populations of black-tailed prairie dog at Las Cienegas National Conservation Area.

Restoration – Native Plants

Monitoring of Cottonwood Seedling Demography in the Missouri Breaks National Monument

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Poster
Key words: Riparian, Monitoring, Geomorphology, Hydrology, Livestock Grazing

The Missouri Breaks National Monument in Montana contains a relatively unmodified portion of the Missouri River. Stands of riparian cottonwood forest are not extensive, but are highly valued in a landscape that is generally too dry to support widespread upland forests. In 1996, we initiated annual monitoring of cottonwood seedlings at eight sites with a range of grazing intensities in order to help resolve the interacting factors controlling the recruitment of new cottonwood forest.

Cottonwood seedlings consistently establish in the bare, moist zone between the high and low water line during the period of cottonwood seed dispersal in early summer each year. Very few of these seedlings survive long enough to become saplings. Side valley constraints on lateral channel movement mean that the physical disturbance from the river creating suitable germination sites also tends to remove seedlings established in previous years. This situation is exaggerated by episodic disturbance from mechanical breakup of ice dams that further restrict safe establishment sites to high bank positions wetted only during relatively infrequent high-flow years. Herbivory interacts with these physical controls. Intense, extended (summer-long) grazing reduces densities of new and surviving seedlings, and most notably limits recruitment of seedlings to taller size classes. The best physical locations for cottonwood forest recruitment in this generally constrained reach of the Missouri River are those with the most potential for channel movement, including locally wide valley sections, around islands, and near tributary junctions.

Native Plant Restoration Project – Kanab High School and Grand Staircase-Escalante National Monument

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Poster
Key words: Education, Collaboration

The Native Plant Restoration Project is an excellent example of the National Landscape Conservation System strategy which supports the restoration of natural and cultural resources, engages in rigorous science, builds beneficial community relationships and encourages youth education.

Science and math students from Kanab High School are assisting the BLM from Grand Staircase-Escalante National Monument (GSENM) and the Kanab Field Office (KFO) to re-establish two native forage plants, winterfat and Indian ricegrass, onto experimental plots.

GSENM and the KFO are concerned about deteriorating rangeland conditions. BLM scientists felt that restoration was possible if the seeds of winterfat and Indian ricegrass could be collected, germinated, raised in greenhouses, and transplanted onto an experimental plot. A lack of funds and personnel time has been a serious impediment until Grand Staircase-Escalante Partners (GSEP) secured two grants for funding an Educational Specialist to work with Kanab High School and oversee the project.

Kanab High School is providing the greenhouse and students to collect the seeds, grow the plants and revegetate the site. Students are using critical thinking skills to design and implement a hands-on science experiment. They are also expanding knowledge of their surrounding by learning about the native plant ecology and habitat zones in the GSENM. Students hope the project results will assist the KFO and GSENM with scientific data to aid rangeland management, and perhaps the project will ignite their interest in becoming the next generation of land managers.

The Native Plant Restoration Project - Grand Staircase-Escalante National Monument

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Oral Presentation
Key words: Education and Collaboration

The Native Plant Restoration Project is an excellent example of the National Landscape Conservation System strategy which supports the restoration of natural and cultural resources, engages in rigorous science, builds beneficial community relationships and encourages youth education.

Grand Staircase-Escalante Partners (Partners), Grand Staircase-Escalante National Monument (GSENM), the BLM Kanab Field Office (KFO), and Kanab High School are jointly working on the Native Plant Restoration Project. The project focuses on the re-establishment of two native forage plants, winterfat and Indian rice grass, on two experimental plots.

The KFO and GSENM are concerned about deteriorating rangeland conditions. On many grazing allotments, earlier BLM projects had replaced native grasses and forbs with non-native species. Grazing and persistent drought conditions have negatively impacted those allotments to the point that native species have virtually disappeared. Currently there is an inadequate number of native species to repopulate the area. BLM scientists felt that restoration was possible if the seeds of winterfat and Indian ricegrass could be collected, germinated, raised in greenhouses, and transplanted onto an experimental plot. However, a lack of funds and personnel time has been a serious impediment.

Partners secured two grants for funding an Educational Specialist to oversee the project. Kanab High School is providing the greenhouse and the student manpower. GSENM and KFO staff are assisting with technical expertise, research design and data analysis.

The project is a collaborative effort which benefits both the BLM and the students. For the KFO and GSENM, the project will: provide scientific data to aid rangeland management decisions, elevate the role of the agencies in educating Kanab youth, and ignite the interest of local youths in land management careers. Students will be using critical thinking skills to design and implement a hands-on science experiment while learning about the native plant ecology and habitat zones in the GSENM.

Monitoring Landscape-Scale Ponderosa Pine Restoration Treatment, Implementation and Effectiveness

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Poster
Key words: Ecological Restoration and Monitoring, Grand Canyon-Parashant National Monument

We evaluated landscape-scale forest restoration treatment implementation and effectiveness in meeting objectives in a ponderosa pine forest at Mt. Trumbull, Grand Canyon-Parashant National Monument in Arizona. The goal of the project was to alter forest structure by thinning and burning to more closely resemble forest conditions prior to Euro-American settlement in 1870. We measured 117 permanent plots before (1996/97) and after (2003) treatments. The plots were evenly distributed across the landscape (~1200 ha), about half of which was an untreated control. We evaluated treatment implementation and effectiveness based on 1870 structure and/or goals outlined by managers. The success of treatment implementation varied: about 94% of the area originally planned for restoration was treated in some manner by 2003, but only 70% received the full planned treatment (thin and burn). Although density of ponderosa pines > 2.5 cm was reduced significantly by 66% from ~429 pines/ha to ~146 pines/ha in the treated area, the targeted residual density was exceeded by 111-256% (all plots) or 10-85% (thinned and burned plots). Thirteen percent of the presettlement pines died in the treated area by 2003 but 9% percent also died in the control, indicating that presettlement pines in untreated areas were nearly as vulnerable as those exposed to restoration treatments. Large snags increased 45%, and 65% of logs >50 cm were retained, achieving implementation goals. Although restoration treatments were not implemented totally to specifications, they were effective in attaining the overall project goal of restoring more open forest structure while preserving more than 75% of the presettlement pines. Canopy fuel loads were substantially reduced, allowing for the reintroduction of surface fires.

Belowground Secrets to Survival: Ectomycorrhizas of Mountain Mahogany

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Poster
Key words: Research, Ecology, Biodiversity, Mycorrhizas, Cascade-Siskiyou National Monument

Curl-leaf mountain mahogany (*Cercocarpus ledifolius*) is a long-lived evergreen shrub or small tree growing on rocky soils in western North America. It is a valuable ecosystem component improving soil conditions through nitrogen-fixing bacteria and providing deer browse. Restoration efforts using mountain mahogany have been largely unsuccessful. Woody species in the Rose family are known to form ectomycorrhizal (EM) associations, but the fungal symbionts have not been identified. Ectomycorrhizal fungi facilitate seedling survival and may link host plants to other trees through mycorrhizal networks. The goal of this study was to distinguish whether the ectomycorrhizal fungi with mountain mahogany are host specific, thereby isolating the plants from other tree species and allowing for greater adaptation to the environment, or whether they are generalist fungi that may form a mycorrhizal network, particularly with scrub oaks (*Quercus garryana var. breweri*). We selected sites in southern Oregon (Medford District BLM and Cascade-Siskiyou National Monument), collected soil samples, sorted mycorrhizal roots, and sequenced the DNA of the internal transcribe spacer (ITS) region to identify ectomycorrhizal fungi. Eighteen species of fungi were identified from ectomycorrhizas of mountain mahogany, five of which were also found on nearby trees of scrub oak. The ectomycorrhizal community of mountain mahogany was distinguished by the presence of an Ascomycete that most closely matches Geopora ("earth-pore" or "fuzzy truffle"), and by the absence of Rhizopogon, any suilloids, and Sebacinales. Shared fungal species show that ectomycorrhizas of mountain mahogany and scrub oak could form a mycorrhizal network, allowing them to exchange nutrients or to share inoculum for seedling roots. Understanding which EM fungi are associated with mountain mahogany will allow for proper selection of mycorrhizal inoculants in restoration efforts.

Flora of the Ironwood Forest National Monument

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Oral Presentation
Key words: Floras, Botanical Foundations

129,000 acres of contiguous BLM managed lands in southern Arizona, just west of Tucson, were designated as Ironwood Forest National Monument (IFNM) in 2000. The Arizona-Sonora Desert Museum conducted the initial biological survey, completed in 2003. The authors of this presentation had been doing research the area independently for several decades before the IFNM's creation, and have continued work to complete the flora since then. A flora is an important tool for setting priorities in development and protection of protected lands. This presentation will discuss what we have learned about the flora of IFNM, what is special there, and discuss the importance of floras.

Restoration – Endangered Species

Augmentation To Increase Genetic Diversity of Four-Petal Pawpaw (*Asimina tetramera*) and to Test the Viability of Tissue Culture Propagated Plantlets as Source Material for Future Introductions

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Poster
Key words: Plant Augmentation and Recovery, Jupiter Inlet Outstanding Natural Area

The four-petal pawpaw, *Asimina tetramera* (Annonaceae), is endemic to the Atlantic coastal ridge in southeast Florida and is both federally and state-listed as endangered. There are 1,300 individuals remaining in 17 scattered populations in Martin and Palm Beach Counties. Although once thought to be connected, most of these populations are thought to now be reproductively isolated from each other, which will most likely continue to deplete existing genetic diversity and reduce population numbers, as outcrossing is the primary breeding system for this species and seedling recruitment is low or non-existent at most sites. The overall project goals are to establish a self-sustaining, genetically diverse population of *Asimina tetramera* at the Jupiter Inlet Lighthouse Outstanding Natural Area and to conduct the first wild planting of tissue culture propagated plantlets of this species. This poster will present the results of the initial 2008 transplant of 132 young pawpaw plantlets to the ONA, and an ongoing collaboration to establish the viability of using tissue culture propagated plants for a population introduction, which can then be useful for future augmentations of plantlets derived from populations that are low in plant numbers or absent in seed production.

Cladonia perforata Transplant at the Bureau of Land Management Jupiter Inlet Lighthouse Outstanding Natural Area

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Poster
Key words: Plant Augmentation and Recovery

Cladonia perforata is known only from about 30 small, xeric sandy sites in Florida rosemary scrub habitat. This distinctive lichen was federally listed as an endangered species by the U.S. Fish and Wildlife Service in 1993. In the recovery plan, five conservation actions were outlined for *C. perforata*, several of which are applicable to this project, namely (1) to protect, manage, and restore known populations, (2) to conduct research on life history and demography, including responses to management and disturbance, and (3) to monitor populations.

At the Jupiter Inlet Lighthouse Outstanding Natural Area (ONA), C. *perforata* occurs in mature Florida scrub predominately in the southern portions of the site. In 2004, hurricane activity significantly damaged mature sand pine near the *C. perforata* population resulting in the toppling of almost all mature sand pine, creating an extensive

litter layer, and promoting the spread of invasive vines, all of which have reduced habitat suitability for *C. perforata*. Prescribed burning is being considered to improve the long term viability of habitat for scrub endemics, including *C. perforata*. However, while adapted to a fire dependent community, *C. perforata* are typically killed by the stand regenerating burns, surviving naturally in unburned patches and slowly recolonizing over decades following the burn. Limited relocation via thallus transplants to suitable unoccupied areas is being explored. This project established additional populations within the ONA to offset any potential loss during future prescribed burns and to move those thalli most vulnerable to damage by prescribed fire. Areas with extensive hurricane windfall where *C. perforata* has managed to persist, but which are vulnerable to proposed burn treatments, were the source of the transplant material. Transplanted thalli were moved to suitable habitat where prescribed burning is not proposed for at least 15 years.

Distribution, Ecology, and Monitoring of the Rare Bruneau River Phlox

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Oral Presentation
Key words: Rare Plants, Ecology, Endemic, Pollination, Wild and Scenic River

The Bruneau River Phlox *(Linanthus glabrum*) was first discovered in 1978 growing high on the canyon walls of its namesake wild and scenic river. It was formally described as a species new to science in 1984. Its global distribution is limited to southwestern Idaho and north-central Nevada. The Bureau of Land Management has designated Bruneau River phlox as a Special Status Species in Nevada and Idaho, where it occurs on vertical or overhanging rhyolitic canyon walls along the inner Bruneau and Jarbidge River canyons in Owyhee County. Monitoring is done by making general ocular population estimates by river section, and by counting individuals within small quadrates at repeatable locations. There are also permanent photo plots. Monitoring data from three of the Idaho sites during 1983 to 2007 revealed Bruneau River phlox is a long-lived subshrub and the populations are relatively stable. The Nose of Sheep Creek monitoring site documents 24 years of longevity for an individual Bruneau River phlox plant. The 2007 ocular population estimate of all Idaho populations is approximately 539 individual plants for the discontinuous 35 miles on the West Fork of the Bruneau, main Bruneau and Jarbidge rivers. Pollination of this night-blooming species is by nocturnal moths. Reproduction of the phlox appears to be occurring but details on establishment on vertical canyon walls are lacking.

Restoration - Riparian

Escalante River Watershed Restoration

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Oral Presentation
Key words: Invasive Species, Restoration, Partnerships

The Escalante River Watershed is located in south central Utah and encompasses Dixie National Forest (DNF), Grand Staircase-Escalante National Monument (GSENM), Glen Canyon National Recreation Area (GLCA), State of Utah lands (SITLA), and private lands. The Escalante River begins west of Escalante, Utah and flows approximately 90 miles to Lake Powell.

GLCA began removing Russian olive and tamarisk from Coyote Gulch, a tributary to the Escalante River, in the mid-1990s. Beginning in 2000, GLCA began working upstream from the confluence with Coyote Gulch to eliminate Russian olive from the Escalante River. In 2006, GSENM and DNF began eradicating Russian olive from their portions of the Escalante River and its tributaries. Through their combined efforts, more than half of the riparian area has been treated.

Following removal of these invasive trees, GSENM has planted native species where previous infestation occurred. Box elder, round-leaf buffalo berry, silver-leaf buffalo berry, big sagebrush, and rabbitbrush have been planted along with willow pole cuttings and cottonwood seedlings. In GLCA, native vegetation has naturally reclaimed areas where infestations previously occurred due in part to relatively natural flooding dynamics in the lower portions of the river corridor. Recovery of native riparian vegetation has exceeded expectations.

Eradication success is being monitored using numerous photo points that were established following the removal efforts. Photo points from the rim of the canyon help determine canopy cover of both native and non-native tree species. Re-treatment of invasive re-growth occurs on an annual basis on the Escalante and bi-annually in the side canyons.

In June of 2009, funding was obtained from the National Park Foundation to create the inter-agency Escalante River Watershed Partnership to pool resources and coordinate control efforts in the watershed. This new partnership, including numerous local stakeholders, is committed to restoring and maintaining the natural ecological conditions of the Escalante River and its watershed to provide for long-term sustainable use.

Tracking Riparian Change in Response to Management Actions at Las Cienegas National Conservation Area

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Oral Presentation
Key words: Riparian, Restoration, Monitoring, Adaptive Management

Las Cienegas National Conservation Area and the surrounding Sonoita Valley Acquisition Planning District were designated by Congress in 2000 to protect and enhance their nationally important resources, including 15 linear stream miles with some of the best remaining riparian and aquatic habitats in the borderland region. Riparian vegetation and channel morphology have changed dramatically since BLM acquired the Las Cienegas property in 1989. During the first 15 years under BLM management, BLM and collaborators fenced progressively longer stream reaches from livestock; removed an irrigation diversion and returned stream flow to an abandoned channel segment; and closed illegal roads crossing the streambed. More recently, BLM has been implementing a vegetation treatment program aimed at reducing mesquite cover and increasing perennial grass cover in the watershed. Riparian monitoring shows these actions are achieving many desired results including improvements

in vegetative bank stability, woody species regeneration, bank soil alteration and significant increases in tree canopy cover throughout Cienega Creek. Aquatic habitat monitoring has shown marsh habitat area more than doubling near the headwaters where channel cross section monitoring has also shown substantial channel aggradation. Other system responses, however, have been unexpected. Pulses of tree recruitment have created patches of dense thickets, some associated with anoxic conditions; this suggests that lack of disturbance may cause problems for native fishes here. In recent years, long-term drought effects may be offsetting some of these gains with substantial reductions in stream flow and length of perennial reaches. Refined monitoring protocols are increasing managers' ability to predict and evaluate effects of their management actions, and will enable them to measure progress towards additional objectives. Review of monitoring results in an adaptive management framework points to the need for alternative restoration and management options for addressing system responses in a rapidly changing environment.

Pakoon Springs: Partnering for Restoration on the Arizona Strip

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Oral Presentation
Key words: Spring Restoration, Partnerships, Grand Canyon- Parashant National Monument

Aridland springs are among the most biologically and culturally diverse, productive ecosystems, but are threatened throughout the West by unsustainable land and resource use practices. Pakoon Springs is a complex of about 10 sources across 56 acres in Grand Wash within Grand Canyon-Parashant National Monument in northwestern Arizona. It is one of the largest spring complexes on the Arizona Strip. Before purchase by the Bureau of Land Management (BLM) in 2003, the site had been used for a century as a cattle (and recently ostrich) ranch and irrigated farm. The BLM and Grand Canyon Wildlands Council (GCWC) initially partnered, funded by the Arizona Water Protection Fund (AWPF; 2000-2001), to inventory the site. An additional grant from AWPF supports the collaborative effort to assess, plan, restore, and monitor the springs.

We used ortho-rectified aerial photography to develop a 0.3 m contour topographic map and mapped the existing sources, structures, and vegetation. BLM removed abandoned equipment, many km of fencing, and dilapidated ranch buildings. Together, we removed non-native tamarisk (*Tamarix* spp.), mosquito fish (*Gambusia affinis*),bullfrogs (*Rana catesbiana*), and a 3 m alligator (*Alligator mississippiensis*). Geomorphic and vegetation rehabilitation activities from 2007-2009 include recontouring excavated sources and berms, and resetting drainages that originally flowed both to the east and west of source areas. Three habitats were of particular interest to reconstruct: wet meadow (ciénega), desert springfed stream, and open water. Following recontouring, we transplanted native wetland and riparian vegetation, and monitored replanting success and natural seedling establishment, finding surprisingly strong recruitment and growth of native plant species. Bullfrog and mosquitofish control efforts are still ongoing, and additional revegetation efforts are needed following incursion of trespass cattle. However, Pakoon Springs ecosystem rehabilitation is well underway and this project has recreated the longest perennial desert stream on this 1.01 million acre national Monument.

Restoration -Fire

Early Revegetation Recovery on a Heavily Visited Mojave Burn: Red Rock Canyon National Conservation Area

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Poster
Key words: Fire, Resource Protection

We examined plant recovery, soils, and soil seed banks on the 348-ha, 2005 Loop Fire in Red Rock Canyon National Conservation Area, 15 km west of metropolitan Las Vegas, Nevada. This burn is of special concern to resource managers because more than 900,000 people visit a scenic Loop Drive encompassed by the burn. We conducted sampling two years after the fire by measuring 10, 0.01-ha plots on the burn and on a paired unburned area. Perennial species composition shifted from dominance by late-successional native shrubs (e.g., blackbrush) on the unburned area to native perennial forbs (e.g., globemallow, desert marigold) on the burn. The burn was more species-rich, with richness of live plants averaging 26 (100 m2 scale) and 239% (1 m^2 scale) greater. Fire and microsite (interspace, below creosote or yucca) interacted to affect 0-5 cm soil properties, with higher pH, conductivity, and total P (phosphorous) and K (potassium) on burned yucca microsites. Red brome density in 0-5 cm soil seed banks was four times lower on the burn, and its distribution among microsites reversed. Below-shrub microsites contained the most brome seeds on the unburned area but the least on the burned area. Intense fire below shrubs may have increased seed mortality, an idea supported by > 3-fold decreases found in emergence density after experimentally heating seed bank samples to 100^{o}C. Our study occurred after a post-fire period of below-average precipitation, underscoring a need for continued monitoring that characterizes moister years and evaluates aesthetic recovery in this heavily visited area.

Post-Fire Seeding Effectiveness in Mojave Desert Communities within Red Rock Canyon National Conservation Area, Southern NV

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Poster
Key words: Post-fire Recovery, Desert Shrublands, Restoration

Mojave ecosystems, especially those in blackbrush habitat are relatively slow to naturally regenerate after fires. Therefore, to restore ecosystem ecological integrity, land managers often utilize active management techniques such as seeding as a method to reintroduce common plant species to burned lands. We monitored seeding effectiveness on two fires within Red Rock Canyon National Conservation Area outside of Las Vegas, NV to evaluate the effectiveness of this strategy for accelerating revegetation. Each site was seeded one year post-fire with different combinations of native species. 2750 acres of the 33,500 acre Goodsprings fire (burned in 2005) were seeded with native perennial species, and approximately 100 acres of the 400 acre Bonnie Springs Fire (burned in 2007) were seeded with a mix of annual and early successional perennial species. We sampled seeded

and unseeded plots for annual and perennial species composition, and collected soil seed bank samples which were grown in the greenhouse at University of Nevada Las Vegas (UNLV) using two techniques to evaluate if 1) seeded species were present in greater abundances in the soil seed bank and 2) seeding had indirect effects on the composition of the seed bank of non-target species. We found varying levels of seeding success. For instance, in the Goodsprings plots desert globemallow was more abundant in seeded plots, while the reverse occurred at the Bonnie Springs sites. However, another common early successional species, desert marigold, was more abundant in seeded sites within the Bonnie Springs fire. Fourwing saltbush was more common in seeded plots, but the species only established successfully on sites with alluvial soils. Our results indicate that seeding can be effective in some circumstances, but without more widely distributed monitoring of treatments like these we cannot determine which factors are most influential in determining seeding success.

General Assumptions about the Non-conifer Landscape Result in Poor Restoration Objectives within Southwest Oregon Chaparral and Woodlands

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Oral Presentation

Key words: Historic Vegetation Condition

Current fire prevention and oak woodland restoration efforts in southwest Oregon are based on the assumption that wildfire perpetuated a more open landscape in historic times. These notions are only partially supported by historic data. Chaparral, commonly assumed by land management agencies to be absent from the historic southwest Oregon landscape is noted on old maps, photos, and anecdotes, while chaparral dynamics with transitional dominance by geophytes following fire is identified in historic and recent fires. While the presence of *Q. garryana* is frequently thought to mark historic oak savanna, General Land Office surveys indicate woodland structure as more common, with the location of savanna on shallow soils, seasonally inundated soils, or soils with shrink-swell mineralogy. Patterns of *Q. garryana* branching structure indicate single-stemmed forms exist more commonly on deeper alluvial soils enabling rapid growth to attain fire-resistant size. Hardwoods at intermediate or higher elevations are frequently multi-trunked identifying the stand replacement role of fire in chaparral and woodland at these sites. Other high elevation stands of *Q. garryana ssp. breweri* exhibit a predisposition for shoot growth from epicormic buds even in the absence of fire. Current meadows and other open areas are associated with specific soil conditions. Fire-mediated meadows of the past have been taken over by conifers, hardwoods, or shrubs. This contraction of meadows and loss of other open fire-mediated vegetation structures serves to reinforce over-generalized assumptions about the historic open nature of the landscape. Restoration/fuel-reduction activities aimed at creating oak savanna in historic canopy-fire ecosystems disrupts chaparral/woodland communities adapted to stand-replacement fire.

A Promising Approach to Fire Rehabilitation in a Southern Utah Pinyon-Juniper Woodland

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Poster
Key words: Fire, Pinyon-Juniper, Rehabilitation, Grand Staircase-Escalante National Monument

In June 2006, a lightning-ignited fire on Buckskin Mountain near the Utah-Arizona state line scorched over 1400 acres of pinyon-juniper woodland in a single day. Poor ecological conditions of earlier fires located in the same region prompted Grand Staircase-Escalante National Monument staff, in cooperation with Utah Division of Wildlife Resources, to immediately begin planning for fire rehabilitation measures to be employed before the following growing season. A native—non-native seed mix was selected with a two-pass Ely chain to cover the seed and to place large standing litter on the ground for better soil stability. Some areas were aerially seeded but not chained due to protection of cultural resources. A comparison between a formerly burned area (1997) nearby and the recently seeded-chained and seeded-not chained areas show much higher native perennial plant and shrub compositions in the seeded-chained area, just three years post burn, than either the existing native-seeded burn or the seeded-not chained areas within the 2006 burn. A question arises whether current conditions will be maintained or will eventually degrade to an invasive annual-dominated site similar to other nearby burned areas.

Seed Removal by Granivorous Ants and Rodents in Burned and Unburned Mojave Desert Habitats: Implication for Revegetation

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Poster
Key words: Fire, Restoration, Granivores

Increased abundance of exotic annual grasses provides fuel for wildfires in North American desert habitats where fires were once uncommon events. Direct seeding techniques are used in an attempt to re-establish native plant species important to desert ecosystem functions and processes. Granivorous ants and rodents are important components of North American deserts, and their seed-consuming behavior can influence plant composition and establishment. Granivores can potentially consume large amounts of the seed used in re-vegetation, possibly slowing restoration efforts. To elucidate seed removal patterns and potential impacts on the seed bank, we carried out a seed removal experiment in burned and unburned creosote (*Larrea tridentata*) scrub communities on BLM managed land near the 2005 Goodsprings Fire in southern Nevada. Our results indicate that seed removal was temporally driven with the largest numbers of seeds removed during summer by both ants and rodents. However, patterns of seed removal differed by habitat type. Rodents removed more seeds in burned (mean ± SE, 5.06 ± 0.40) than unburned (2.80 ± 0.33) habitat, and ants removed a higher number of seeds in unburned (6.45 ± 0.59) than in burned (2.91 ± 0.29) habitat. It appears that rodents are removing more seeds of a large-seeded species, *Coleogyne ramosissima*, (seed mass, 15.86 ± 0.61 mg) while ants are selecting seeds of small-seeded species, Penstemon bicolor [0.54 ± 0.11 mg], *Encelia farinosa* [1.00 ± 0.10 mg], and *Sphaeralcea ambigua* [1.09 ± 0.08 mg]. Our results suggest that granivorous ants and rodents may play a significant role in the establishment of plant communities in burned areas by removing a significant number of seeds. Therefore, land managers may choose to implement restoration efforts when ant and rodent activity is low in winter months.

Restoration - Invasive Species

Engaging Citizen Stewards in Restoration Partnerships: A Case Study of the Paria River

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Poster
Key words: Restoration Ecology, Monitoring, Citizen Science, Volunteers, Paria Canyon-Vermilion Cliffs Wilderness, Vermilion Cliffs National Monument

In 2005, the Grand Canyon Trust and The Conservation Fund jointly purchased the Kane and Two Mile ranches, whose livestock grazing permits extend across nearly 850,000 acres of public land north of the Grand Canyon. The main objective of this venture is to influence a conservation-based public lands management paradigm that includes strong science, strong public involvement, and active collaborations. Following a rapid ecological assessment of the ranches' landscape in 2005, we identified Paria Canyon in Vermilion Cliffs National Monument as an area with high potential for successful tamarisk and Russian olive removal, as the flood regime is relatively intact and natural recruitment of native species is likely due to the presence of native vegetation in surrounding areas. In 2007, we formed a partnership with the BLM, the Arizona Water Protection Fund, and a large constituency of volunteers to remove tamarisk and Russian olive from a 21-mile stretch of river, beginning just upstream of the Grand Canyon Trust grazing allotments at the southern border of Grand Staircase-Escalante National Monument.

Work began in the fall of 2008 and is expected to continue through 2013. We have developed a comprehensive monitoring plan that will allow us to track changes in floodplain structure, vegetation, soils, and avian communities associated with invasive species removals. Monitoring will be implemented utilizing a combination of trained field technicians and volunteers. In addition, we are developing a core group of "master volunteers" that are engaged with other regional restoration efforts and will provide higher-level project implementation capacity, working with Trust staff and partners throughout the duration of the project. Lessons learned during this initial effort will be used to adaptively move forward in developing a plan for controlling these species throughout the Paria River drainage and in the greater Grand Canyon region.

Monitoring the Invasion of Bufflegrass (*Pennisetum ciliare*) in Ironwood Forest National Monument

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Oral Presentation
Key words: Invasive Species

The Arizona-Sonora Desert Museum (ASDM) conducted the initial biological survey of Ironwood Forest National Monument (IFNM), completed in 2003. Identification of threats from invasive species was one of our tasks. In

2005 ASDM conducted a more detailed analysis of the extent and biological effects of buffelgrass invasion in IFNM and in Sonora, Mexico. Four areas of the Monument had significant infestations of exotic buffelgrass (*Pennisetum ciliare*) in 2003, and there were numerous small pioneer patches. In the intervening few years the invasion has expanded so dramatically that it is clearly evident to casual observers who are familiar with the region. In 2010 ASDM remapped the extent of the invasion to identify the areas where the spread is greatest. BLM will use the data to determine where to focus control efforts.

Invasive Resistance and Persistence: Established Plants Win, Even with Disturbance and High Propagule Pressure

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Poster
Key words: Restoration Ecology, Grand Canyon-Parashant National Monument

Disturbances and propagule pressure are key mechanisms in plant community resistance to invasion as well as persistence of invasions, but few studies have experimentally tested the interaction of these two mechanisms. We initiated a study in a southwestern ponderosa pine (*Pinus ponderosa Laws*.)/bunch grass system to determine the susceptibility of remnant native vegetation to cheatgrass (*Bromus tectorum L*.) invasion, and persistence of cheatgrass in invaded areas. We used a 2 x 2 factorial design consisting of a biomass removal (clipped), reciprocal seeding (seeded), clipped and seeded treatments, and untreated controls. We seeded cheatgrass seeds in native plots and a native seed mixture in cheatgrass plots. Two biomass removal disturbances and sowing seeds over three years did not reverse cheatgrass dominance in invaded patches or native grass dominance in uninvaded native plots. Our results suggest that two factors dictated the persistence of the resident communities. First, differences in levels of plant-available soil nitrogen and phosphorus favored the dominant species in each community. Second, bottlebrush squirreltail (*Elymus elymoides* (Raf.) *Swezey*) was the dominant native herbaceous species on the study site. This species is typically a poor competitor with cheatgrass as a seedling, but is a strong competitor when mature. Our study shows that soil properties and established plants can strongly buffer the impacts of disturbance and elevated propagule pressure.

Preliminary Evaluation of the Invasive Species Forecasting System in Grand Staircase-Escalante National Monument

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Oral Presentation
Key words: Habitat Suitability Modeling, Invasive Species, Cheatgrass

NASA's Applied Sciences Program is working with various bureaus within the Department of Interior to develop the Invasive Species Forecasting System (ISFS). ISFS is intended to help resource managers understand the potential distribution of invasive terrestrial plants. Decision support tools built using ISFS allow users to load point occurrence field sample data for a plant species of interest, then quickly generate predictive habitat suitability maps for geographic regions of management concern, such as a national park, monument, forest, or wilderness or wilderness study area. This type of decision product helps resource managers plan invasive species protection, monitoring, and control strategies for the lands they manage. We conducted a preliminary evaluation of ISFS at the Bureau of Land Management's Grand Staircase-Escalante National Monument (GSENM). Covering approximately 1.9 million acres, GSENM is the largest monument in the continental United States. Vast expanses of some of the nation's harshest terrain separate field offices and work locations, making GSENM an ideal place to test ISFS's unique deployment approach, which enables the rapid adaption and construction of lightweight applications for regionalized use. A key element of this approach is the use of private-sector networking capabilities combined with an asynchronous runtime implementation of ISFS on personal laptop computers that provide modeling capabilities to users without requiring constant connection to the Internet. In this paper, we will provide an overview of the ISFS project, the technical innovations contributing to ISFS's success, and preliminary studies focusing on the habitat suitability of cheatgrass in the Monument. The approach taken here could provide a new model for the agile delivery of data and services to a wide range of science research and inventory and monitoring decision support applications of value to the National Landscape Conservation System.

Historical Cover Types and Riparian Management along the Missouri River in the Upper Missouri River Breaks National Monument

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Oral Presentation
Key words: Riparian, Historical Cover, Land Use Practices, Geomorphology

The Missouri River through the Upper Missouri River Breaks National Monument in Montana retains much of the character it had when traversed by Lewis and Clark. The historical cover types provide a valuable context for evaluating the relative roles of human actions (water management, grazing, direct cover type conversions, introduction and control of non-native Russian olive) and natural geomorphic (valley width) and climatic (episodic ice drives) constraints on the current cottonwood forest.

We examined changes in riparian cover types derived from early 1890's maps produced by the Missouri River Commission and aerial imagery from 2006 and the early 1950's. There are three geomorphically distinct reaches: Fort Benton to the Marias River confluence (approximately 70 river km in a relatively wide valley); the Marias River confluence to Grand Island (approximately 150 river km in a narrow, post-glacial valley); and Grand Island to Fort Peck Reservoir (approximately 25 km in a relatively wide valley). In the middle and most constrained reach, the relatively small area of riparian forest has changed very little from the 1890's to 2006. Most conversion to urban and other developed cover types has occurred in the Fort Benton to Marias River reach. Riparian forest has increased in this upper reach since the 1890's with some of the increase composed of Russian-olive stands. The short, lower reach near Fort Peck reservoir has substantially more riparian forest per river length than the other reaches, but has lost forest area during the period examined. All these reaches have experienced channel

narrowing or loss of channel area since the 1890's, likely a result of a combination of flow attenuation from upstream water management and climatic shifts since the 1800's.

Monitoring

Keys to Successful Rangeland Adaptive Management for the Las Cienegas National Conservation Area's Grassland Watershed: Focus, Commitment and Transparency

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Oral Presentation
Key words: Rangeland, Monitoring, Adaptive Management

The Las Cienegas National Conservation Area supports some of the Southwest's best remaining semi-desert grassland. In 2004, BLM invited The Nature Conservancy to review the ability of existing monitoring to (1) measure progress towards BLM's grassland management objectives, and (2) provide warning signals when conditions approached key ecological thresholds. This review led to modifications that increased its power to detect change in ground and grass cover, and added an estimate of shrub cover to address thresholds for irreversible conversion to shrubland. Adding paired exclosures boosted the program's ability to distinguish direct grazing effects from other impacts. Reducing emphasis on protocols that did not inform BLM objectives enabled teams to collect more robust data without increasing fieldwork required per plot.

The BLM uses monitoring data—along with discussions about recent data and long-term trends with the permittee and multi-stakeholder teams—to adjust annual grazing and fire plans and ensure that watershed objectives are being met. Participants have progressively improved this decision-making cycle by making sure data gets analyzed quickly, compared with BLM objectives, and discussed at stakeholder meetings; using field visits to develop consensus on how to recuperate underperforming sites; timing data collection and agency decisions with livestock shipping dates to better enable the permittee to respond to site conditions; and making the process more transparent by using data to anchor discussions and work through concerns together. Continued use of ecological state and transition models has helped diverse stakeholders communicate about grassland dynamics and relate data to thresholds. Increased use of data in decision-making has built support for continued implementation of robust monitoring and involvement of stakeholders. Openness and transparency of the process has built trust. We found three years of involvement to be a minimum for giving this process time to take root. Additional years have continued to solidify the partnership's progress.

Post-Treatment Erosion of Excavated Stream Crossings in Headwaters Forest Reserve, California

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Poster
Key words: Restoration, Erosion, Monitoring

At the time of the Headwaters Forest Reserve acquisition in 1999, the Reserve contained 50 miles of abandoned logging roads, mostly constructed near streams and posing a high risk of erosion. Beginning in 2000 the BLM initiated a program to systematically remove these roads using heavy equipment in order to minimize future erosion. A potential impact of road removal is post-project erosion from excavated areas. One of the objectives of this project was to determine the volume of post-treatment erosion occurring from stream crossing excavations.

Measurements were taken at 27 crossings within 2 years following excavation. Repeat measurements were taken in subsequent years to determine the quantity of erosion through time. The dimensions of individual erosional voids were recorded, volumes were calculated for each feature, and a total erosion volume was calculated for each crossing. Post-treatment erosion volumes were categorized into two types: incision and bank failure. The total volume for all 27 sites was 318.3 m^3, which equals 0.04% of the total volume excavated for the sites monitored. Monitoring found channel incision to be the predominant erosion process accounting for the greatest proportion of erosion. Repeat measurements suggest that the bulk of the observed erosion (>98 percent) occurs within the first two years following treatment. As an adaptive management measure, woody debris is now being placed at the bottom of some excavated channels to reduce incision.

What Happens when the Cows Come Off? A Unique Opportunity for Collaboration and Research

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Poster
Key words: Partnerships, Collaboration, Research, Las Cienegas National Conservation Area

An innovative experiment – large-scale exclusion of domestic livestock from rangeland – is providing insight into natural processes and guidance for management of southwestern grasslands. The Appleton-Whittell Research Ranch, an 8000 acre ecological research station and sanctuary for native plants and animals, is a cooperative effort among the Bureau of Land Management, National Audubon Society, Swift Current Land and Cattle Co., The Nature Conservancy of Arizona, The Research Ranch Foundation, and the U.S. Forest Service. Comprising the southernmost portion of Las Cienegas National Conservation Area (NCA) in southeastern Arizona, the Research Ranch is managed by Audubon under a combination of contractual and cooperative agreements with the various landowners. Ungrazed by domestic livestock since 1968 and surrounded by active cattle ranches, the Research Ranch provides a control or reference area for cross-fence research projects on topics including native and invasive species, fire, riparian systems, and shrub encroachment. More recently a new role has emerged for the Research Ranch as a reference area by which to evaluate the impacts of exurbanization as the human population in the areas increases. Several hundred scientific publications and numerous management guidelines have resulted from past research, and over forty research and monitoring projects are ongoing. The first annual Science Symposium of the Sonoita Valley, held in May of 2009, hosted by the Sonoita Valley Planning Partnership and held at the Research Ranch, shared results from research on Las Cienegas NCA with community members.

Taking the Pulse of Our Planet: The USA National Phenology Network

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Oral Presentation
Key words: Partnerships and Collaboration, Climate Change, Education, Outreach, Citizen Science

Patterns of phenology for plants and animals control ecosystem processes, determine land surface properties, control biosphere-atmosphere interactions, and affect food production, health, conservation, and recreation. The USA National Phenology Network (USA-NPN; www.usanpn.org) is an emerging and exciting partnership between federal agencies, the academic community, and the general public to establish a national science and monitoring initiative focused on phenology as a tool to understand how plants, animals and landscapes respond to climate variation, and as a tool to facilitate human adaptation to ongoing and potential future climate change. A solid understanding of recent and potential future changes in phenology across the National Landscape Conservation System can help us understand observed changes in ecological and physical processes over the last decade, as well as forecast potential future changes under rapidly changing environments. In its second year of operation, USA-NPN produced many new phenology products and venues for phenology research and citizen involvement. A new web-page contains an advanced on-line user interface to facilitate entry of contemporary data into the National Phenology Database. The new plant phenology monitoring program provides standardized methods and monitoring protocols for 215 local, regional, and nationally distributed plant species. Monitoring methods have been modified to facilitate collection of sampling intensity and absence data for both plants and animals; animal monitoring protocols will be added in March 2010. Coordinated development of regional networks will facilitate focused communication and interaction around regional phenology issues. Future directions include increased integration with national and international formal and informal science networks; enhanced consistency and availability of remote sensing of phenology terminology, methods, products and services; tools for discovery, description, ingestion, curation and distribution of historic phenology datasets; and, improvement of tools for data entry, download and visualization.

Hydrology

Water Science on the Agua Fria National Monument

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Poster
Key words: Partnerships and Collaboration

The Friends of the Agua Fria National Monument (FAFNM), has participated with other organizations to assess the functional condition of the Agua Fria River using two protocols. The first protocol is called Wet-Dry Mapping. In this protocol volunteers (approximately 20 including volunteers from surrounding communities) hike or ride horseback on the streambed during the driest time of the year (June 21) to determine where surface water is present. The presence and absence of water is documented with handheld GPS units and the findings mapped to determine the fraction of the river that contains surface water. The FAFNM has partnered with the University of

Arizona to receive training on the protocol and conducting the actual assessment. The second protocol is called the Rapid Stream-Riparian Assessment (RSRA), developed for use on streams of the Colorado Plateau and, by extension, on other southwest streams. The FAFNM has partnered with the Arizona Riparian Council and Audubon Arizona in receiving training on the protocol and conducting actual assessments of 25 indicators of stream function on the Agua Fria River and tributaries.

Our poster will display the activities and results of FAFNM members participating in these activities.

Investigations into Water Quality Issues in Calf Creek, Garfield County, UT

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Poster
Key words: Water Quality, Fisheries, Grand Staircase-Escalante National Monument

Calf Creek is a perennial tributary to the Escalante River and is located within Grand Staircase-Escalante National Monument (GSENM). Calf Creek has been classified by the State of Utah as a cold water fishery and is stocked with brown trout. In the harsh environments of the GSENM, it is a vital riparian area supporting biological and botanical diversity. Additionally, Calf Creek is enjoyed by thousands of people every year because of its picturesque redrock setting and unique set of waterfalls.

Routine water quality monitoring has indicated that Calf Creek is exceeding the temperature standard for cold water fisheries, and a study has been initiated to find out why this exceedance is occurring. Submersible data loggers have been installed along the stream to collect daily temperature fluctuations and to help isolate those reaches where temperature excesses are occurring. Data has also been collected for the proceeding two years during single day monitoring trips along the entire length of Calf Creek. With the completion of sampling in fall 2010, it is anticipated that the exceedances can be pinpointed to exact locations that may or may not affect the stream's classification.

If, however, temperatures have risen too high to support a cold water fishery classification, why have the changes occurred? Some of the questions to be asked include: is recreation having an impact on the creek, can vegetative management change the stream's temperature, what other changes may have occurred to increase the stream's temperature? Through these investigations, we look forward to better understanding Calf Creek's hydrologic and biological systems.

Wildlife

Mammals

Survival of Pronghorn Fawns on the Carrizo Plain National Monument: Relationships between Predation, Birth Synchrony, and Habitat

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Oral Presentation
Key words: Wildlife Research, Carrizo Plain National Monument

On Carrizo Plain National Monument in California, the translocated population of pronghorn antelope (*Antilocapra americana*) has experienced a 20 year history of population fluctuation and overall decline. Research on pronghorn within the Monument is limited and little is known about fawn survival, one of the most critical factors involved in pronghorn population trends. The primary objective of our study is to identify the factors affecting fawn survival. Specifically, we will examine relationships between survival, habitat use, predation, weather, diet, and birth synchrony. In 2009 we outfitted fawns with lightweight GPS and remote downloading collars which obtain precise and frequent locations on a scale that has not been possible in the past. Here, we present preliminary results from our first field season. Our final results will provide information that can be used by resource managers to increase fawn survival and ultimately predict population trends on the Monument.

Cattle vs. Endangered Kangaroo Rats: Optimizing Multi-Use in the Carrizo Plain National Monument, California

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Poster
Key words: Wildlife Management, Conservation, Grazing, Carrizo Plain National Monument

Livestock grazing on public lands is a key component of many human-wildlife conflicts, but moderate to light grazing may benefit grassland wildlife by maintaining open habitat conditions. We initiated a large-scale exclosure experiment in the Carrizo Plain National Monument, California, to investigate the interactions between livestock, native wildlife, and the plant community. We found that the federally endangered giant kangaroo rat (*Dipodomys ingens*) plays a keystone role in the system, providing refuge habitat for other wildlife and altering plant composition via foraging and soil disturbance. Cattle grazing has not been detrimental or beneficial to giant kangaroo rats during the past two years. Monitoring experimental plots over time will reveal the effect of cattle grazing on this keystone species and help optimize multi-use management of the Monument.

Birds

Responses of Nesting Raptors to Habitat Alteration in the Morley Nelson Snake River Birds of Prey National Conservation Area

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Oral Presentation
Key words: Long-term Research, Monitoring, Climate Change

Morley Nelson Snake River Birds of Prey National Conservation Area (NCA) contains the most significant aggregation of nesting raptors in North America and perhaps the World. Wildfires, land uses, and drought have interacted to cause extensive habitat changes in the NCA. Although some nesting species, particularly those on the plateau, were relatively resilient to habitat changes cause by wildfire and military training, Golden Eagles and Prairie Falcons were less resilient. Preliminary results show a significant negative trend for the number of eagle pairs in the NCA with 30% decline between 1971 and 2009. The decline in number of occupied eagle nesting territories, combined with the apparent decline in black-tailed jackrabbits (the eagle's major prey) suggests a reduced carrying capacity for Golden Eagles in the NCA. Eagle productivity showed no significant trend over time. We suggest that the less productive territories in the NCA became vacant and that a core of pairs in productive territories produced most young for the population. Preliminary results show no significant trend in the number of Prairie Falcon pairs between 1976 and 2003; the number of pairs in 2002 (217) was highest ever observed in the NCA. Falcon productivity in 2003 was lower than in any years except 1982 and 1993. Prairie Falcon reproduction in the NCA is closely tied to ground squirrel abundance. Changes in falcon abundance and productivity may reflect changes in ground squirrel abundance. Piute ground squirrel populations respond negatively to drought and show more variability in exotic annual grass communities than in native shrub habitats. Habitat and climatic changes apparently have resulted in greater annual fluctuations in falcon abundance and productivity. Conservation actions include wildfire suppression and restoration of native shrubs and perennial grasses within Golden Eagle and Prairie Falcon foraging areas, and subsequent monitoring, integrated at all three trophic levels.

Ten Years of Research on Grassland Birds in Arizona, Including BLM's Las Cienegas National Conservation Area

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Oral Presentation
Key words: Research, Grassland Birds, Partnership, Collaboration

Research on winter and breeding ecology and distribution of grassland birds has been conducted in semi-desert and plains grasslands of southeastern Arizona on BLM's Las Cienegas National Conservation Area, as well as Audubon Research Ranch, US Forest Service, USFWS, and private ranch lands. This research has been supported by multiple funding (and in-kind) sources and has also involved large numbers of field volunteers. Research has

included six years of work on wintering habitat associations of grassland birds, three years of post-wildfire research, two years of work on breeding distribution and abundance of Arizona Grasshopper Sparrow, and the first of three years of funding (NLCS) for research on breeding ecology of Arizona Grasshopper Sparrow. This presentation will summarize information about (1) the associations of a suite of winter sparrow species with habitat characteristics such as shrub density, grass density, bare ground, dead litter, and exotic grass; (2) comparisons between historic and current surveys of Arizona Grasshopper Sparrow distribution and abundance; and (3) some preliminary information about the new study of breeding ecology of Arizona Grasshopper Sparrow. Information will be presented in the context of the partnerships and collaboration that made this research possible.

Effects of Grassland Restoration Efforts on Birds on Las Cienegas National Conservation Area, Arizona

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Oral Presentation
Key words: Restoration, Wildlife, Fire, Land Use

The structure of all grassland ecosystems in the southwestern US has changed markedly as a result of human activities, which affects the ecological function of these systems and the ability of these areas to function as habitat for animals. Two primary drivers of these changes are the introduction of nonnative plants and suppression of natural ecosystem drivers, such as wildfire. BLM has sought to restore the structure and function of native grasslands on Las Cienegas National Conservation Area (LCNCA) in southern Arizona by reducing encroachment of shrubs that have increased in abundance considerably during the last 100 years through three restoration treatments: prescribed fire, mechanical removal, and herbicide. From 2005 to 2009, we evaluated the effects of these restoration treatments on breeding songbirds that we surveyed eight times per year on 40 permanent plots established across LCNCA. We found that all restoration treatments affected populations of breeding birds and composition of the overall bird community. In general, effects of fire on bird abundance were relatively short-lived (typically <3 years) because fire primarily affected grasses that were quick to recover; in contrast, mechanical removal and herbicide application had longer-duration effects on birds because the treatments more permanently altered density and cover of shrubs that are important determinants of community structure for grasslands birds. Overall, the restoration treatments we studied had positive effects on grassland-associated birds, which bode well for recovery of these threatened ecosystems.

Citizen Science for Managing Terrestrial Maritime Habitats on the California Coastal National Monument

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Oral Presentation
Key words: Conservation Biology, Partnerships and Collaboration

Growth of coastal communities in California is increasing the likelihood of significant human impacts to the flora and fauna of California Coastal National Monument. The 16,000 rock islands and 1,100-mile length of the Monument require that the BLM build a new framework for science to inform management that protects seabirds, marine mammals, and rare terrestrial plants. Involving area residents in scientific studies and monitoring is raising public awareness and curbing human disturbances to the Monument. A study of impacts from a fireworks display on a nesting colony of Brandt's Cormorant (*Phalacrocorax penicillatus*) in 2007 galvanized the interest of local communities to expand monitoring of seabirds to all seasons and to other parts of the Monument in Mendocino and Sonoma counties. Current seabird studies include: long-term seabird population studies at Gualala Point Island and in Noyo Bay; historical changes in habitat use by seabirds on Fish Rocks; and island carrying capacity for nesting seabird as sea level rises.

The BLM also works with Non-Governmental Organizations (NGOs) in Sonoma County communities to contribute to and expand the existing National Park Service network to monitor populations and health of marine mammals regionally. Research on habitat use and modeling will begin in 2010. Botanists from community colleges and citizen groups are using high-powered optics and photography to inventory and document plant species on rock islands. Thus far, botanists have found two BLM sensitive plant species previously unrecorded off the mainland. The BLM and the Sea Ranch CCNM Task Force have initiated the first vegetation project for the Monument to coordinate recovery of the rare grass, *Agrostis blasdalei*, on Shell Beach Island and the adjoining mainland.

Fisheries

Bonita Creek Native Fish Restoration

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Oral Presentation
Key words: Partnership and Collaboration, Gila Box Riparian Natural Area

Native fishes historically found in the Gila River basin have suffered significant declines in abundance and distribution due to nonnative fishes and habitat loss and degradation. To reverse this trend, nonnative fishes must be segregated from native fishes and the habitat protected to prevent future reinvasions. Within Gila Box Riparian Natural Area, Bonita Creek in Graham County, AZ, is considered a high priority for native fish recovery in the Gila River basin due to its assemblage of five native fishes (Gila chub, *Gila intermedia*, longfin dace, *Agosia chrysogaster*, speckled dace, *Rhinichthys osculus*, Sonora sucker, *Catostomus insignis*, and desert sucker, *Pantosteus clarki*) uncontaminated by nonnative fishes and other nonnative aquatic organisms in upper reaches of the stream, habitats appropriate for introduction of additional federally-listed fishes native to the Gila River basin, and its potential to be protected against impacts/invasions of nonnative fishes by constructing a fish barrier and chemically removing the nonnatives. For native fish recovery, a fish barrier was constructed across Bonita Creek

by the Bureau of Reclamation in 2008. The barrier is a 160-foot wide concrete-reinforced arched structure with a four-foot tall crest, and is protected against stream scouring with sunken keys and rip-rap emplaced downstream of the apron. To remove nonnative fish species, Bonita Creek was chemically renovated. Renovation included and required beaver pond breaching, native fish salvage, chemical application of the piscicide rotenone (CFT Legumine), and repatriation of the salvaged natives. To facilitate the project, approximately 46 beaver ponds were temporarily breached to lower the pools and to establish greater flow, which was necessary to effectively disperse the piscicide through the stream. Prior to chemical treatment native fish and Sonora mud turtles were salvaged using a combination of electrofishing, seines, hoop nets, and minnow traps. Captured native fishes were held in flow-through holding tanks. To determine the amount of rotenone necessary, stream discharge and volume were calculated using direct measurements and a fluorescent dye. Rotenone was applied using constant-flow drip stations while roving crews treated shallow backwaters and poorly-mixed shorelines with backpack sprayers. Approximately 2.6 miles of stream was chemically treated twice. To verify a complete kill after the piscicide treatment, hoop nets and minnow traps were set in pool and run habitats and the entire creek was electrofished. No fish were found alive. Sentinel native fish were placed into live cars for two days to ensure the stream had detoxified before the salvaged fish and turtles were repatriated back to the stream near the general vicinity from where they were captured. Federally-listed loach minnow, *Tiaroga cobitis*, spikedace, *Meda fulgida*, desert pupfish, *Cyprinodon macularius*, and Gila topminnow, *Poeciliopsis occidentalis* were also introduced following detoxification. The project was a collaborative effort among Arizona Game and Fish Department, Bureau of Land Management, Bureau of Reclamation, U.S. Fish and Wildlife Service, City of Safford, Arizona State University, University of Arizona, and public volunteers.

The Power to See Change: Designing More Effective, More Efficient Monitoring for Population Trends in the Endangered Gila Topminnow

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Poster
Key words: Power Analysis, Trend Analysis, Gila topminnow, *Poecilliopsis occidentalis*, Monitoring, Adaptive Management, Las Cienegas National Conservation Area

Las Cienegas National Conservation Area supports the nation's best remaining wild population of endangered Gila topminnow. BLM has monitored fish and their habitats annually since 1989, to screen for disease and non-native fishes, track topminnow population trends, and evaluate how management actions affect the fish. We present results from 15 years of BLM fish data, test the monitoring program's ability to detect important changes, and evaluate options for improving efficiency and effectiveness. Both Cienega Creek perennial reaches continue to support topminnow, which remain abundant in some locations; exotics have not invaded. However, by 2005, topminnow abundance in upper reach monitoring sites had dropped to less than two percent of 1989 levels. Causes of decline are unclear but may include drought and habitat changes from lack of disturbance. Lower reach sites have not suffered such extreme drops, but highly variable fish counts make it difficult to reliably determine whether topminnow populations in this reach have been stable, decreasing, or even increasing through time.

To give managers more reliable and timely information about population trends, we used simulation-based power analyses to test a suite of possible variations on existing monitoring protocols, examining tradeoffs between sampling design and precision. We looked for modifications that would enable managers to detect trends that

double or halve the population over either eight or ten-year spans; preserve the ability to compare new results with long-term data sets; and could be implemented without increasing monitoring effort. Adding lower reach sampling stations improves change detection in the species' current stronghold, with only slightly more effort. Simultaneously shifting topminnow sampling to every-other-year reduces effort while retaining improved statistical power and enabling staff to satisfy other needs in alternate years, e.g. surveying other species. Randomly locating new stations enables inference to the whole reach; keeping some original locations provides continuity with past data.

Archaeology

Persistent Connectivity across Central Arizona during the 14th Century: Evaluating the Verde Confederacy Model with Ceramics from Perry Mesa

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Oral Presentation
Key words: Agua Fria National Monument, Perry Mesa, Prehistoric Warfare, Alliance, Ceramics

Population movement was endemic to the prehistoric Southwest, and archaeologists have devoted much research to explaining this mobility. In central Arizona, one proposed model for population movement onto Perry Mesa in the 14th century is the Verde Confederacy, described as a large-scale, coordinated alliance among village clusters along the middle Verde River, in Bloody Basin, and on Perry Mesa. According to this model, the Perry Mesa occupation was a strategic deployment to shore up the western flank of the alliance. The Alliance and Landscape project has focused on evaluating the Verde Confederacy model, which postulates coordinated action and persistent connectivity among the alliance members across the region. This paper evaluates one aspect of the model (persistent connectivity) with ceramic-exchange data. Petrographic characterizations of the temper and chemical assays of the clay fractions in the plain ware pottery have identified distinct compositional differences in the clay containers produced at different settlements in different parts of the confederacy region, allowing us to track the movement of pots between villages. Preliminary data indicate the presence of two exchange spheres focused on Perry Mesa and settlements in the Verde River valley. These patterns hint at social boundaries among groups instead of a single, coordinated alliance.

Red Rock National Conservation Area, What Changes Have Occurred with Cultural Management?

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Oral Presentation
Key words: Cultural Resource Management, Red Rock Canyon National Conservation Area

In the 2005, the *State of the National Landscape Conservation System* cited "insufficient data available" to assess the management of cultural resources on the Red Rock Canyon National Conservation Area (RRCNCA). This

presentation will cover recent work on the RRCNCA that indicates an improvement concerning the cultural resources, highlighting the Site Steward program in Southern Nevada, recent surveys that have located/ranked many sites and culturally significant areas by risk/ threats, potential for interpretation, and future proscriptive management practices based particularly on increased visitorship. Integral to meeting the BLMs objectives to better manage culturally significant areas on RRCNCA, has been the enhancement of more effective partnerships with groups such as the Nevada Rock Art Foundation (NRAF), Friends of Red Rock Canyon Cultural Resources Team, and local academic institutions. Using the criteria for cultural resource management set forth in the *State of the National Landscape Conservation System*, the presentation will provide an overview of the significant, demonstrable improvements to the Red Rock Canyon NCA cultural resource program.

Lead, Murals, and Pottery: Tracing Technologies and Peoples of Lowry Pueblo Great House, Southwest Colorado

Sally Cole[3], Mona Charles[3] and Marvin Rowe[4]
Presenter: LINDA FARNSWORTH[1]
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Poster
Key words: Research, Southwestern Archaeology, Canyons of the Ancients National Monument

This poster presents the results of non-destructive testing of pigments used in kiva murals at Lowry Pueblo, and painted pottery from the Durango area, with a hand-held x-ray fluorescence spectrometer. These examinations revealed unusually high concentrations of lead, zinc, and arsenic-exceeding current maximum permissible limits in solid materials that are toxic. The research examines the implications of the use of lead pigment in murals and on ceramics on our understanding of prehistoric group identities, interaction, and migrations in the Northern San Juan Basin between approximately AD 600 and AD 1170. The research also found that the established visual standard for differentiating organic from mineral paint on pottery, widely used in the Southwest, may be unreliable.

Numerous additional research directions are suggested, including the examining the effect of toxic concentrations of lead on population dynamics and health as well as the relationship of the pigment technology in a prehistoric cultural context.

The Long Gulch Mesa Archaeological Inventory Project: New Research on the Agua Fria National Monument

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Oral Presentation
Key words: Archaeological Survey

The Agua Fria National Monument (AFNM), part of the National Landscape Conservation System, is located in central Arizona 40 miles north of Phoenix. It was established 10 years ago primarily to preserve and protect the important and substantial prehistoric cultural resources found on a significant portion of the remaining high desert grassland in the state. Encompassing approximately 7000 acres, Long Gulch Mesa lies north of Perry Mesa between Silver Creek and Indian Creek, most of which is administered by the BLM. The Tonto National Forest manages the eastern quarter. In contrast to the attention that Perry Mesa has received, most notably in recent years, almost nothing is known about the archaeology of Long Gulch Mesa or the northern portion of the AFNM, about 40% of the Monument. The Long Gulch Mesa Archaeological Inventory Project is a multiyear effort to address that issue. This presentation reveals the results of the recent fieldwork.

Canyons of the Ancients National Monument Cultural Landscapes

Natalie Fast[1]
Presenter: LINDA FARNSWORTH[1]
[1]Canyons of the Ancients National Monument, Dolores, CO

Poster
Key words: Research, Archaeolgical Inventory, Landscape Management

Southwest Colorado has been a focal point for archaeological research and exploration for more than 130 years. Since 2000, Canyons of the Ancients National Monument has implemented the landscape management philosophy of the BLM's National Landscape Conservation System, and has been conducting an ambitious program of intensive cultural resource inventories. These inventories have examined 13,500 acres and documented 1,192 sites. In all, approximately 26 percent of the Monument has been inventoried, an unprecedented coverage for a BLM area. This poster will provide a synthesis of inventory results and the new information that has been learned about settlement and land use in the Monument through time.

The Lawhead Gulch Shelter: Archaeological Investigations at an Archaic Period Occupation in the Gunnison Gorge National Conservation Area

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Oral Presentation
Key words: Scientific Discovery, Education, Excavation

The Lawhead Gulch Rockshelter is a prehistoric occupation and rock art site situated on the north bank of the Gunnison River at the north end of the Gunnison Gorge National Conservation Area in Delta County, Colorado. Due to extensive surface vandalism, the site was chosen for a testing, evaluation and interpretation program in cooperation with Western Wyoming College's archaeology program. Test excavations began in the summer of 2006 with archaeology students and volunteers. During our excavations, we have learned that the site had been used and occupied by people for more than 7,000 years. The nature of the rock art in the shelter supports this long term occupation as do the varied projectile point styles recovered in excavation. In this paper we will focus

on the nature and extent the better defined occupation horizons and offer some tentative conclusions about how the site's inhabitants made a living.

Impacts of Prehistoric Land Use Intensity on Ecological Legacies in the Arid US Southwest

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Oral Presentation
Key words: Land Use, Prehistoric Agriculture

Numerous studies have shown that past land use is important in structuring modern ecological communities in terrestrial systems. For example, data across forest, grassland, and desert ecosystems suggest that post-colonial and prehistoric agricultural activities can affect species assemblages and soil properties. But are all prehistoric activities equal in their long-term impacts, or are there some which "disappear" from the ecological canvas over time? In collaboration with archaeologists, we are exploring this question across a gradient of human land use intensity in central Arizona, which supported agro-ecologically active and well studied populations of humans until 1200-1400 AD. Our results suggest that prehistoric farming left long-term legacies in soil water holding capacity by altering rock distribution and soil texture. Stone density within rock alignments and the slope of prehistoric fields is significantly related to sand content of soil within agricultural terraces, allowing deeper drainage that was likely beneficial for crops. Despite these alterations to soil properties, prehistoric farming had an insignificant impact on soil nutrient content and primary production of annual vegetation in the desert grasslands of Agua Fria National Monument.

Successful Collaboration in the El Malpais National Conservation Area, New Mexico

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Oral Presentation
Key words: Human History, Dendrochronology

For the past four years, the New Mexico BLM (Rio Puerco Field Office), Laboratory of Tree-Ring Research (University of Arizona), and Manzanares Research, Inc. have collaborated on projects in the El Malpais National Conservation Area in western New Mexico. Goals of the collaboration have included site documentation, research, and student training. New technologies and approaches have improved site documentation for preservation and management purposes, while research has identified an early 20th century Navajo use of the area and delineated additional aspects of a later Anglo-American occupation under the Homestead Act. Although homesteading was ultimately unsuccessful in the area, attempts at water control by the homesteaders continue to influence the landscape today, and contribute to management and conservation issues for the BLM. The dendrochronological research generated under this partnership is providing valuable information for managers and for scholars alike. International and US students and professionals have been trained in the collection, analysis, and interpretation of archaeological tree-ring samples.

Cultural Resources of the Headwaters Forest Reserve: Archaeological Traces of the Life and Times of Humans in the Old Growth Redwood Forest

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Oral Presentation
Key words: Archaeology, Education, National Register of Historic Places

The Headwaters Forest Reserve protects one of the last, previously unprotected, large stands of old growth redwood forest on California's north coast. The nearly 7,500 acres of cooperatively-managed lands have been home to generations of various peoples over the past millennia, each of which utilized the forest in different ways. This paper presents what has been learned through various archaeological field investigations and archival research of past human use of the Headwaters Forest. The knowledge resulting from these studies allows the BLM to present interpretive information that integrates the natural and cultural realms within the Reserve. Increased understanding of the nature of cultural resources within the Reserve also allows for adaptive management that promotes public appreciation of both the natural and cultural resources the BLM protects.

Connecting Natural and Cultural Histories on the Las Cienegas National Conservation Area in Southern Arizona

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Oral Presentation
Key words: Natural History, Cultural History, Environmental Change, Geomorphology

A recent discovery of human skeletal material more than three meters below modern surface in Las Cienegas Creek provides an opportunity for non-destructive geomorphological research as part of an effort to date the time of deposition of the human remains. The geomorphological research, including relative and absolute dating of soils and organic materials, has allowed natural and cultural scientists to reconstruct the age, sequence, and severity of different types of human impacts on the ecosystem of the Las Cienegas Creek National Conservation Area, as inferred from sediment types and deposition rates. The geomorphological data are combined with the archaeological, ethnohistoric, and historic records of the area in an effort to better understand the environmental effects of different cultural and socioeconomic systems. This research uses data from NLCS units to better understand how humans affect the environment, and how changes in the environment dictate change in human adaptations.

Archaeological Information Technology [Computing] in BLM's NLCS, throughout BLM and Beyond

DAN MARTIN[1], Derrick Baldwin[2], Jeanne Moe[3] and Neffra Matthews[1]
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Poster
Key words: Information Technology

This poster will present a review of the development and application of Information Technology [Computing Capabilities] (including world wide web tools, Geographic Information Suytems, Remote Sensing, GPS, etc.) by the Bureau of Land Management, its partners, and researchers to create a body of work that has contributed to the science of archaeology as well as a better understanding of BLM resources.

Settlement Analysis at White Knolls: Vermilion Cliffs National Monument

DOUG MCFADDEN[1]
Presenter: RICK MOORE[2]
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[2]Grand Canyon Trust, Flagstaff, AZ

Poster
Key words: Archaeological Inventory, Paria Plateau

This poster describes recent inventory on the Paria Plateau, Vermilion Cliffs National Monument, supported by the Grand Canyon Trust, the Arizona Strip District BLM and the Vermilion Cliffs – Kaibab Heritage Alliance. The research focuses on the White Knolls community where exceptional preservation of architecture allows detailed observations on site-site and site-environmental relationships. Pueblo layouts allow definition of household size and organization. Small site distribution patterns there describe a close association of field houses with natural basin features which are proposed as the focus of a local form of dry farm agriculture. Occupation at a White Knolls spans a period of intense drought (AD 1133-1177) when dry farming would have been untenable. The architectural record suggests that the plateau may have been depopulated during this period and reoccupied during Pueblo III times. Enclosed plaza architecture, increases in storage capacity, and defensible pueblo locations emerge during Pueblo III suggesting that incipient social reorganization and strife may characterize the terminal occupation.

Archaic Peoples of Grand Staircase-Escalante National Monument

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Oral Presentation
Key words: Archaeology, Archaic Period, Hunter-gatherers

The Archaic is commonly considered a mobile hunting-gathering lifeway that developed in response to the extinction of Pleistocene megafauna and the evolution of post-glacial environments that persisted up until the introduction of agriculture. The Archaic period (7000 BC – 1 AD) is commonly divided into three intervals – early, middle, and late – each having a distinct material culture within the larger shared material culture. Cultural resource inventories on Grand Staircase-Escalante National Monument indicate a considerable Archaic presence. Despite the abundance of evidence, the Archaic period has garnered minimal research interest.

The majority of research has concentrated on the Anasazi and the Fremont archaeological cultures of the subsequent Formative period (1 AD – 1300 AD), which is characterized by the practice of agriculture, substantial architectural construction, long-term storage facilities, and the production of pottery. As a result, some attention has been given to the late Archaic period (1800 BC – 1 AD), as this interval is important to Formative studies for defining the natural and social environment in which agriculture was introduced. However, most Archaic research on the Monument has either coincided with large inventory projects that contained Archaic sites within the project area or excavations at Formative sites that revealed underlying Archaic components.

This presentation will offer an overview of the Archaic archaeological record on Grand Staircase-Escalante National Monument and develop research questions for future study of the Archaic.

Changing Patterns of Resistance and Conflict in West-Central Arizona, AD 1100-1425

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Poster
Key words: Settlement Patterns, Prehistoric Conflict, Agua Fria National Monument

Beginning with the premise that early warning is essential to security, the Museum of Northern Arizona in 1997 began a "Hilltop Survey" in all of west-central Arizona and now over 800 sites have been recorded from the air and many have been recorded by pedestrian survey. Field checking and computer studies of line-of-sight among these sites have revealed striking patterns of integration, division, and boundaries. A theory of resistance and conflict is postulated to explain these patterns. Fundamental changes involving regional depopulation of large areas and coalescence into larger sites in optimal places occurred ca. AD 1275, resulting in strikingly new settlement patterns suggesting an escalation of conflict with the Phoenix Basin Hohokam to the south and engagement in a Hopi macroeconomy of long-distance trade to the northeast. New archaeological surveys document patterns that partly bring into question the "Verde Confederacy" model initially inferred to explain some of these changes. Tensions within the proposed confederacy are now documented, and that it split apart between AD 1325 and 1350. Strong connectivity from Polles Mesa to Perry Mesa is more fully documented by the distribution of Hopi Yellow Ware and Roosevelt Red Ware.

Research Partnerships in Wilderness Study Areas: the Archaeology of Chaco Period Communities and the Challenges of Collaboration

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Oral Presentation
Key words: Chacoan Frontier, Subsistence, Land Use, Great Houses

The Mesita Blanca and Eagle Peak Wilderness Study Areas (WSAs) in remote western Catron County, New Mexico hold keys to understanding life on the Chaco system's southern frontier.

Washington State University's Dr. Andrew Duff, in partnership with BLM's Socorro Field Office, initiated the ongoing project in 2002. Focusing on two Chaco period greathouse pueblos and their sustaining communities, data from excavations have provided new insights into the founding of regional occupation, the homelands of source populations, interactions between distant great house communities and Chaco Canyon, and aspects of local community organization, subsistence, land use and ritual.

This paper summarizes results of the research to date, and describes the involvement of the four Western Pueblos in the project.

Paleodemography and Climate Change in the Carrizo Plain National Monument, California

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Oral Presentation
Key words: Archaeology, Human Responses to Climate Change

The Carrizo Plain National Monument (CPNM), California, contains a remarkable concentration of prehistoric archaeological sites. These include the world-renowned pictograph site, Painted Rock, which is a key component of an existing National Register of Historic Places rock art district, as well as the centerpiece of an 89 sites district recently nominated as a National Historic Landmark. BLM-sponsored archaeological inventories of the CPNM have resulted in the discovery and documentation of a previously unknown but large number of village deposits associated with the rock art sites. Chronological evidence indicates that the CPNM sites date from the Paleoindian (~10,000 YBP) to the Historic period (~AD 1800). But the large majority of the villages and the rock art sites are Middle Period (4000 – 800 YBP) in age, with a much smaller number of Late Prehistoric (800-200 YBP) and Historic villages. Paleodemographic reconstructions suggest that the transition from the Middle to Late Prehistoric Periods involved a 90% drop in population. Based on Eigenbroad's analyses of lacustrine deposits from Soda Lake, this transitional period and population collapse correspond to the Medieval Climatic Anomaly, which was marked by prolonged droughts. The CPNM evidence is contextualized by simultaneous cultural and population shifts in surrounding regions. These indicate that human responses to dramatic climatic changes are variable and sometimes involve lagged time-responses, making their archaeological identification and analysis especially difficult.

Obsidian on Grand Staircase-Escalante National Monument: Who Broke the Glass on the Staircase?

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Oral Presentation
Key words: Archaeology, Obsidian, Land Use Patterns

Obsidian does not occur naturally on the Grand Staircase, but is found occasionally on archaeological sites and as isolated artifacts across this rugged portion of the Colorado Plateau. Obsidian was one of the favorite tool-quality stones used in prehistoric times due to its easy workability and ability to produce very sharp edges. Ongoing research compares the obsidian found on Formative (Anasazi) sites versus hunter-gatherer sites, and traces the obsidian to a variety of sources from northern Idaho to central Arizona although the majority of the material comes from eastern Great Basin sources. The obsidian appears to have arrived primarily in the Archaic and Late Prehistoric periods, and demonstrates a continuity of lifeways across both these periods that ties use of the Grand Staircase region and the Great Basin together for thousands of years. Surprisingly, almost no obsidian has been dated to the Formative period. There is also evidence of curation and re-use over time, complicating an already complex picture. Through examination of the obsidian from different sources and the timing of when it arrived on the Grand Staircase-Escalante National Monument, interesting patterns emerge that provide clues to past land use patterns, and raise yet additional research questions.

The Tommy Turf Site 42Ka6032; A Basketmaker II Burial from Kane County, UT

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Oral Presentation
Key words: Archaeology, Basketmaker II, Grand Staircase-Escalante National Monument

In October of 2004, water line installation at the privately owned Tommy Turf Farm in Kanab, Utah, encountered an apparent prehistoric multiple burial. At the request of the State Historic Preservation Office (SHPO) the staff archaeologist at Grand Staircase-Escalante National Monument undertook the excavation of this important site as an agent of the State of Utah. The resulting archaeological excavation revealed a single-episode burial of at least ten individuals ranging in age from a neonate to elderly adults. Both males and females are represented in the burial. Interestingly, while some of the interred individuals were primary burials, it appears that others within the single burial pit may have been interred as secondary burials. Carbon dating revealed that this burial falls within the calibrated, 2 Sigma range of 200 BC to 70 AD, or the Basketmaker II period. This is an important period in the prehistory of the American Southwest, as the Basketmaker II era represents the transition from a hunting-and-gathering lifestyle to that of full-time horticulture, and pre-dates the advent of pottery. Stable isotope analysis of the human remains indicates a population heavily dependent on maize agriculture, indicating that these were indeed farmers.

This site is situated on a low, open ridge top, contrasting with other Grand Staircase-Escalante area BM-II multiple burials which have been located in rock shelters and alcoves. Osteological analysis identified well healed antemortem trauma, evidence of generalized infection, indications of habitual activities, osteoarthritis, and poor dental health among the individuals. No perimortem trauma was indentified among the remains of the mass grave, and cause of death could not be identified although sickness is suspected.

Tribal Consultation and Partnerships

Beyond NAGPRA: Native Voice Interpretation at the Anasazi Heritage Center and Canyons of the Ancients National Monument

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Oral Presentation
Key words: Interpretation, American Indian, Cultural Resources

This presentation will describe the interpretation/consultation template which has been used successfully on such NLCS projects as Ancient Images and Pueblo Perspectives, the *Visit with Respect* film project, and the 2010 Sand Canyon Trail brochure.

With images from these projects, the presentation will illustrate the critical roles of partnerships [e.g. Colorado Historical Society State Historical Fund grants, etc.], developing trust relationships with American Indians and Crow Canyon Archaeological Center staff, and directly working together with tribal members and preservation offices at their offices and homes.

An Innovative Federal and Tribal NLCS Partnership: Kasha-Katuwe Tent Rocks NM, New Mexico

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Oral Presentation
Key words: Partnerships and Collaboration, Kasha-Katuwe Tent Rocks National Monument, Cochiti Pueblo

The Bureau of Land Management forged a successful partnership with the Pueblo de Cochiti, as a result of the designation of (KKTRNM). The Pueblo de Cochiti serves as the gateway community to these unique formations of wind- and water-eroded volcanic tuff sculptures. The Monument is located between Albuquerque and Santa Fe, attracting over 60,000 visitors a year. Beginning at the grass-roots level in 1997, the Bureau of Land Management and the Pueblo de Cochiti signed a Cooperative Management Agreement to provide for joint management of Tent Rocks Area of Critical Environmental Concern, ensure access to the public, preserve the tranquility of the Pueblo community, and protect the geologic values of the site. A unique Inter-Governmental Cooperative Agreement was signed in 2000 to provide benefits for natural resource program coordination, public and Pueblo land-use planning, economic benefit, and ongoing protection of culturally sensitive areas. Today, the staffing at KKTR is comprised of Pueblo de Cochiti tribal members who convey the life ways of their people and culture to the visiting public. This joint management under the partnership agreement has served to enhance efforts to protect the natural and traditional cultural values at KKTR while striving to increase visitors' understanding, enjoyment, and experience in this unique natural and cultural landscape of this NLCS unit.

The Native Voice and Sacred Sites on Public Lands: Painted Rock of the Carrizo Plain National Monument

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Oral Presentation
Key words: Native American Consultation, Site Management, Rock Art

The outstanding cultural resources on the Carrizo Plain National Monument embody the mission statement of the NLCS system which states as a goal the conservation and protection of landscapes recognized for their nationally significant values. The core of the Carrizo prehistoric cultural landscape is the Carrizo Plain Discontiguous Rock Art District, 24 pictograph sites listed at the National level of significance on the National Register of Historic Places, and recently nominated along with 65 additional prehistoric archaeological sites as a National Historic Landmark. An important element in the management of these cultural sites has been the inclusion of the local Native American community in the planning process. The world-renowned pictograph site at Painted Rock is considered to be a sacred site by the Chumash, Yokuts and Salinan people. For more than a decade, the Carrizo Native American Advisory Committee has been a central element in planning and management related to Painted Rock. This paper will discuss the importance of the Native American consultation process to the management of sacred landscapes.

History

The Southern Utah Oral History Project: A Record of Living with the Land

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Oral Presentation
Key words: Oral History, Cultural History, Collection, Preservation, Land Use, Grand Staircase-Escalante National Monument

The Southern Oral History Project began in July 1998 when Grand Staircase-Escalante National Monument (GSENM) was established and administrators wanted to gather historical life ways and land use information from the surrounding communities. Local citizens in the small communities in Kane and Garfield counties of southern Utah, that border the Monument, manifest great interest in documenting and preserving the cultural history of the area. Funding for the project came from the Bureau of Land Management. Grand Staircase-Escalante National Monument and Utah State Historical Society staffs entered into a partnership to carry out the project with the Utah State Historical Society. The aim of the oral history project is to preserve some of the memories and culture of long-time residents of the area. Preserving cultural history through oral history collection allows communities to survive by continuing to retell their stories, building bridges between the past and present, and enabling local residents and visitors to the Monument and surrounding communities to engage in the area's unique culture.

National Scenic and Historic Trails: Finding and Preserving Historic Trails in the Developing West

Iditarod Trail Centennial – An Opportunity for Collaboration

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Oral Presentation
Key words: National Historic Trails, Field Investigation, Preservation, Public/Private Partnerships

This presentation will focus on the educational, outreach, and preservation programs undertaken as part of the celebration of the Iditarod centennial.

The Iditarod National Historic Trail, designated a national historic trial in 1978, is celebrating its centennial over a five year period, from 2008 to 2012. A *Centennial Framework*, which identifies goals and projects for the centennial years, is a collaborative effort between the Iditarod Historic Trail Alliance, Bureau of Land Management (trail administrator), the Chugach National Forest, U.S. Fish and Wildlife Service, and the State of Alaska. Divided into three categories, the Trail, the Story and Stewardship, projects identified in the *Centennial Framework* can be undertaken by any party interested in joining the centennial celebration. The discussion will focus on successful collaborative initiatives and projects at the halfway point in the five year celebration. These include 1) building safety cabins in remote stretches of the Iditarod Trail in partnership with nearby local communities, 2) adjudicatiion of right-of-ways on state land, 3) partnering with the Alaska State Fair and developing educational exhibits, 4) participating in activities during the annual Iditarod Sled Dog Race, and 5) the first steps in developing iTREC! (Iditarod Trail In Every Classroom), a placed-based education and service learning model professional teacher development workshop series connecting communities, schools, and the Iditarod Trail based on Appalachian Trail and Forest Service educational programs.

Protecting National Historic Trails: Landscape Documentation and Section 106

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Oral Presentation
Key words: National Historic Trails, Field Investigation, Preservation, Public/Private Partnerships

The Advisory Council on Historic Preservation oversees other federal agencies as they fulfill the National Historic Preservation Act's Section 106 process. This process involves consultation, led by the federal agency, with State Historic Preservation Officers, Indian tribes, local governments, project proponents, and other interested parties about the effects of a proposed project on historic properties. One of the challenges of completing the Section 106 process for historic trails has been a lack of landscape-scale information about the sites. While trail locations, ruts, and associated buildings may be documented, often the larger landscape has not been holistically

documented. Good documentation on the topography, vegetation, viewsheds, and water sources which influenced the choice of route can strengthen the voice of trail advocates faced with proposed projects that will adversely effect historic trails. As the nation seeks energy independence, the number of proposed projects and transmission lines is already challenging those who are concerned about preserving our history. Finding the balance between the future and the past is never easy, but having better landscape documentation will improve the preservation outcomes on Section 106 consultation.

Constructed Roads and Traveled Trails: Rediscovering and Preserving the Oregon-California Trail through a Western Wyoming Gas Field

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Oral Presentation
Key words: California National Historic Trail, Lander Road, Oil and Gas Development

Recent historical research in the Pinedale Anticline natural gas field has discovered a previously forgotten branch of Lander's Cut-off of the Oregon-California Trail in Western Wyoming. Also known as the Lander Road, this route afforded emigrants a short-cut between South Pass, Wyoming and Fort Hall, Idaho. Officially designated as part of the California National Historic Trail (CNHT) and formally known as the Central Division of the Fort Kearney, South Pass, and Honey Lake Wagon Road, the Lander Road was the first federally funded road west of the Mississippi. In response to a cry for a better, safer, and more practicable route to the West, the Lander Road was built by the Department of Interior (DOI) in 1858, under the supervision of Col. Frederick Lander. This constructed route was mapped for the DOI by Lander's chief engineer, William Wagner, that same year. A detailed analysis of Wagner's maps and other historical documents indicates that two branches of the Lander Road traverse the Pinedale Anticline. This research proves that the recently identified branch was the original route, designed and constructed by Lander and that the designated route of the CNHT is actually a later manifestation of the Road. Tracks and swale remnants of this original route have been confirmed across the Anticline and subsurface testing has identified artifacts that may be directly related with Lander and his road building team. The Pinedale Anticline is one of the nation's most active natural gas fields, where preservation of historical integrity is challenging. The BLM Pinedale Field Office is meeting this challenge by implementing a multi-use management strategy and developing a conservation easement that will preserve the setting, swales, and campsites of the Lander Road, permit responsible natural gas development, and increase public access, interpretation and education along this section of the National Historic Trail.

Tracking Down a Trail: Preliminary Inventory Results for a Portion of the East Fork of the North Branch of the Old Spanish Trail

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Oral Presentation
Key words: National Historic Trails, Field Investigation, Preservation, Public/Private Partnerships

In 2008, several BLM parcels near a section of the East Fork of the North Branch of the Old Spanish Trail (OST) were identified for potential oil and gas development. Because the OST was not recognized in the San Luis Resource Area Resource Management Plan (RMP), the Center Manager chose to defer the parcels until more information on trail locations and potential visual impacts could be gathered. This discussion will focus on the preliminary results of a first attempt at ground-truthing the OST in this area. In 2009, an inventory was conducted by RMC Consultants Inc. on a selection of BLM managed lands that intersect or are adjacent to the congressionally designated OST at the base of the Sangre de Cristos in the northeastern portion of the San Luis Valley, Colorado. Methodology included a combination of archival research/GIS mapping, intensive inventory, and metal detecting. One potential OST trail segment and one archaeological site containing artifacts that appear to date to the OST time period (metal points, trade beads, metal tinklers, a musket ball, and a scrolled metal bit fragment) were recorded. In addition, the inventory also documented other resources including a Clovis site and a late 1800s/early 1900s period historic site. We will also explore the challenges of managing the OST as a 'concept', the rewards of working with knowledgeable locals, and focusing the efforts of the land manager and the archaeologist on field identification and management of an under-studied and fascinating resource.

The Camino Real in New Mexico: An Investigation

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Oral Presentation
Key words: National Historic Trails, Field Investigation, Preservation, Public/Private Partnerships

In cooperation and consultation with the long distance trails programs of the National Park Service and Bureau of Land Management and with the Historic Preservation Division, Department of Cultural Affairs of the State of New Mexico, Merlan Associates is writing a multiple property National Register nomination of the Camino Real in New Mexico. We will talk about our means and methods, our historical research and our investigations in the field. There are many matters of definition and approach to be dealt with. The Camino is more than three hundred miles long in New Mexico and runs through Texas into Mexico: how much of it, or of its least disturbed segments, can we record? How have we dealt with the fact that significant parts of the Camino are on private property, whose owners generally distrust the idea of preservation? How can we cooperate with another state and another country to shape this nomination for greatest consistency and as a basis for future research? How do we bring together the general history (the "multiple property" text) and the physical examination, analysis and presentation of the different segments, such that they explain one another and make a whole picture? On segments where the Camino is virtually invisible today, we use various documents and imagery, including for example Soil Conservation Service aerials which are now historic documents in themselves, to find parts of it, but are we in certain places pursuing an idea more than a visible reality, and if this is the case, how much latitude can we responsibly claim? Can we look to the future and offer advice about preservation and protection?

Protecting the Old Spanish National Historic Trail

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Oral Presentation
Key words: National Historic Trails, Field Investigation, Preservation, Public/Private Partnerships

Last year the Old Spanish Trail Association (OSTA), Chupadero Archeological Resources, LLC and the Arizona Strip District of the Bureau of Land Management (BLM) started working together to locate, document and assess the condition of the Old Spanish National Historic Trail as it crosses northern Arizona and portions of southern Utah. Once trail segments and associated sites are found and documented, they and the trail corridor will be periodically monitored to assess archeological features, trail bed and trail corridor changes by OSTA Trail Stewards, a new program currently being organized and implemented by the OSTA and the BLM. This new partnership provides an opportunity to recruit and train volunteers to assist the BLM and other Federal agencies in finding, documenting and protecting a national historic trail that otherwise would not have been documented and protected.

Future community developments in this remote and developing region of the Southwest may impact the historic trail and its historic setting. The project will help Federal agencies focus protection on trail segments and associated sites that currently retain their integrity and/or historic setting on Federally-administered lands and will allow the BLM, by working with local communities, to interpret and enhance recreational enjoyment of the most appropriate trail segments and associated sites. The project should also build capacity for local OSTA chapters in northern Arizona, southern Nevada and southern Utah, and increase the pool of volunteers available to assist Federal agencies in finding, recording, monitoring, preserving and promoting the Old Spanish National Historic Trail in this region.

Identification and Challenges for the Conservation of Parts of the Camino Real de Tierra Adentro in the State Of Durango, Mexico

Identificación y Retos para la Conservación de Tramos Del Camino Real de Tierra Adentro en el Estado de Durango, México

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Oral Presentation
Key words: National Historic Trails, Field Investigation, Preservation, Public/Private Partnerships

Durante el 2008 y 2009, se realizaron una serie de trabajos de campo que culminaron con la identificación de 19 sitios que representaran el itinerario cultural del Camino Real de Tierra Adentro en el estado de Durango, para su inclusión en el expediente para buscar la declaratoria de patrimonio mundial por parte de la UNESCO. En el presente trabajo presentamos las distintas categorías de sitios incluidos: ciudades, villas de españoles, pueblos de indios, misiones, presidios, haciendas, tramos del camino, puentes, reales de minas, así como sitios indígenas de arte rupestre asociados al Camino Real.

Por otra parte, la particularidad del trazo del Camino Real de Tierra Adentro en el actual estado de Durango, hace que la identificación de tramos preservados de este sea una tarea ardua que conlleva un trabajo de prospección arqueológica y trabajo histórico, donde serán los referentes geográficos del paisaje unos de los elementos

fundamentales para la identificación de este. De esta manera, se presentaran los trabajos realizados entre los poblados de Nazas y San Pedro del Gallo, como un ejemplo de identificación del camino.

Esta diversidad de sitios históricos presenta importantes retos para la conservación, especialmente para los tramos del Camino Real de Tierra Adentro, los cuales al no tener elementos construidos los hace muy vulnerables, lo que nos lleva a plantear distintas estrategias de conservación.

During 2008 and 2009, we carried out a series of field programs that culminated with the identification of 19 places that represent the cultural itinerary of El Camino Real de Tierra Adentro in the state of Durango. This work supported our nomination of El Camino Real de Tierra Adentro to the UNESCO World Heritage List. Our presentation describes the different categories included for the declaration: cities, villages of Spaniards, towns of Indians, missions, presidios, haciendas, tracts of the road, bridges, real de minas, or mining districts, as well as indigenous rock art districts associated with El Camino Real de Tierra Adentro.

The identification of preserved tracts of El Camino Real de Tierra Adentro in the modern state of Durango is an arduous task that requires a combination of archaeological and historic research to establish and identify the fundamental elements and geographical referents of the landscape. Here, we present the works carried out between the towns of Nazas and San Pedro del Gallo as an example of our approach to identification of the historic road and route.

This diversity of historical places and resources associated with historic routes presents important challenges for conservation. This is especially true for those tracts of the Camino Real de Tierra Adentro which were established by use, but which lack built or constructed elements. These tracts are very vulnerable and will require the development of different conservation strategies.

Wyoming's National Historic Trails and Wind Energy Development

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Oral Presentation
Key words: National Historic Trails, Field Investigation, Preservation, Public/Private Partnerships

Wyoming has long, pristine segments of the National Historic Trails predominantly on public lands. The area surrounding the NHTs has high wind energy potential, generating a virtual "land-grab" on the part of wind companies. BLM must balance both conservation and multiple use mandates. Making the challenge more difficult is BLM's national wind policy, which excludes NLCS units from development. However, the national policy fails to identify what should be included in this exclusion area for NHTs. Is it trail ruts or the entire viewshed or something in between? Wyoming BLM struggles to answer these questions and develop consistent management strategies.

Documenting and Preserving Historic Trails in the National Landscape Conservation System

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Oral Presentation
Key words: National Historic Trails, Field Investigation, Preservation, Public/Private Partnerships

Codification of the National Landscape Conservation System (NLCS) in 2009 represented a huge step forward for the recognition and preservation of the Bureau of Land Management's (BLM) most significant lands and resources, including nine national historic trails. As linear landscapes that represent human movement and connectivity within and between diverse ecosystems, trails require unique strategies for management and protection. Not only must the physical paths or corridors of travel be identified and preserved, but the associated places, buildings and structures and the full sensory experience of journeying through and past intact natural environments must be protected. Trails enable us to see unique and beautiful landscapes firsthand and to experience the adventure, wonder and challenges that prehistoric and historic people felt. In addition, trail corridors represent ideal places for learning about long-term, mutually influential relationships between people and environments. Hence, preserving the defining characteristics of national historic trails requires protecting a set of related physical, visual and ecosystem elements. Documenting and understanding interrelated resources is vital for their preservation and one of the principles of the NLCS is to be an outdoor laboratory for scientific research that aids in the restoration and stewardship of landscapes. Accordingly, this presentation discusses methods for, and the value of, researching diverse aspects of national historic trails. It also provides examples of how improved documentation of linear landscapes leads to their more effective protection.

Visual Resource Inventory, Visual Resource Management, and the National Historic Trails

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Oral Presentation
Key words: National Historic Trails, Field Investigation, Preservation, Public/Private Partnerships

This presentation will describe the BLM's Visual Resource Inventory and landscape documentation initiatives and discuss recent BLM efforts to develop consistent protocols for identifying and evaluating visual resources associated with national historic trails and similar features of the National Landscape Conservation System.

Wild and Scenic Rivers

Citizen – Student Monitoring of a Wild and Scenic River

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Oral Presentation
Key words: Educational Partnership, Community Collaboration, Crooked Wild and Scenic River

The Crook County School District Natural Resources Education Program (NREP) has adopted the Crooked River Watershed as an outdoor classroom. One of the many projects involved is the monitoring of the Outstandingly Remarkable Values (ORVs) of the Crooked Wild and Scenic River (CWSR) as prescribed by the interagency river management plan. Under a BLM NLCS science grant, students from the high school are monitoring various natural resource and social components of the designated river corridor. This monitoring project is being coordinated with a variety of Federal, State and local organizations. Partners in the program include: Oregon Department of Fish and Game, Oregon Department of Environmental Quality, Crooked River Watershed Council, City of Prineville, and Wolftree (a non-profit science education organization). Students are completing the various monitoring task under the guidance of high school and local college/ university faculty. This holistic, long term monitoring of nine river values is a unique program in the Wild and Scenic River System. The adoption of the CWSR monitoring implements an unfulfilled requirement of the 1992 river management plan. Monitoring ORVs is a critical aspect of Wild and Scenic River management; however as in the case of the CWSR, it is often neglected or never initiated. This citizen-student based monitoring of ORVs may set a precedent on how agencies can fulfill their obligation to protect and enhance the identified values of an NLCS unit. This presentation will provide an overview of the NREP and discuss how the CWSR project is providing critical baseline data as well as monitoring of anticipated changes in the watershed.

Outstandingly Remarkable Value Based Science on a National Wild River: The Gulkana River, Alaska

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Oral Presentation

Key words: Outstanding Resource Values (ORVs), Wildlife, Fish, Water Quality, Boating, Gulkana Wild and Scenic River

The Gulkana Wild River was designated in 1980 under the Alaska National Interest Lands Conservation Act, and therefore did not have Outstandingly Remarkable Values (ORVs) identified at the time the river was designated. The Gulkana River is the largest clear-water tributary to the Copper River, and supports substantial populations of salmon and Arctic grayling. The river is road accessible in places, with campgrounds and boat ramps, and is therefore a popular destination for in-state and out of state tourists, recreationists, and fishermen. Research and monitoring activities have been occurring in some cases for 30 years, and were used to help identify the river's outstandingly remarkable values which were adopted in the Revised River Management Plan, completed in 2006. These research and monitoring activities include Chinook salmon spawning habitat identification and escapement monitoring, rainbow trout spawning area identification and population estimates, bald eagle productivity surveys, moose and caribou population monitoring, water flow assessment and water quality monitoring. These science based activities directly contribute to the protection and management of the ORVs of 1) fish and fish habitat, 2) wildlife and wildlife viewing, 3) boating, and 4) water quality.

Wilderness

Wilderness and Research: A Peaceful Coexistence

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Oral Presentation
Key words: Paleocene Vertebrate Fossils, Conservation, Wilderness

The Bisti/De-Na-Zin Wilderness Area is one of the San Juan Basin's unique and remarkable geologic structures with significant paleontological values. It includes some of the few exposures of Late Cretaceous and Early Paleocene vertebrate fossils in stratigraphic superposition in North America. These fossil resources are of scientific and educational importance and are managed as a resource warranting scientific collection and conservation.

Collection or removal of paleontological resources from the wilderness areas are generally considered incompatible with the concept of wilderness preservation. In order for the scientific community and public to benefit from the Bisti/De-Na-Zin Wilderness Area, significant fossils should be removed through systematic collection programs to provide further wilderness benefits. Collection of vertebrate fossils by competent professionals in this wilderness area can be entirely compatible with the concept of wilderness preservation.

Professional paleontological field work in the BDNZ is not a "consumptive" activity. At the current rate of one to two permits per year, field work by professional paleontologists who monitor and collect surface fossils eroding within the BDNZ Wilderness will continue to have little or no impact on the resource or the area's wilderness character. Large excavations are handled on a case-by-case basis and must be approved by the State Director. The partial skull of a new genus and species of Tyrannoosauroid, the "Bisti Beast" was collected in 1998. It was collected under the first Paleontological Excavation Permit authorized by the State Director for collection in a designated wilderness.

Removal of fossils from a wilderness area need not interfere with the wilderness values that provide outstanding opportunities for primitive recreation and outdoor laboratory study. Paleontological resources are important supplemental values of wilderness and should be preserved in museums. Excavation of the Bisti Beast is an excellent example of the manner in which paleontological research and wilderness preservation can co-exist.

Wilderness: An Unexpected Second Chance

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Poster
Key words: Wilderness Characteristics, Changing Land Conditions

Bureau of Land Management (BLM), which administers 256 million acres of federal surface and 700 million acres of subsurface mineral estate in the U.S., was belatedly added to the list of agencies authorized, through the 1964

Wilderness Act, to inventory, study and manage wilderness areas. The Federal Land Policy & Management Act of 1976, which established the BLM as an agency that would manage lands "in perpetuity," included a provision directing the BLM to inventory the public lands for areas possessing wilderness characteristics and to manage such "wilderness study areas" (WSAs) to preserve their wilderness characteristics until such time as Congress either designates them as wilderness or releases them from further wilderness study. BLM conducted these inventories and studies between 1976 and 1991, finding nearly 800 areas totaling approximately 24 million acres to possess wilderness characteristics. Today, BLM manages 222 Wilderness Areas totaling 8.6 million acres, and close to 545 Wilderness Study Areas totaling 12.7 million acres.

Areas not found to possess wilderness characteristics were released from "interim management" protection. Over time it was presumed that, in the absence of special protection, lands outside WSAs would be further degraded by uses not allowed within WSAs. In the 20-30 years that have elapsed since the original inventories, however, circumstances have, in a surprising number of areas, combined to reverse factors that formerly precluded them from meeting minimum wilderness criteria. Using Oregon public lands as an example, this paper highlights events, prompted largely by non-governmental organizations conducting "citizen inventories," and renewed wilderness inventory efforts conducted by the BLM, that have led to an unexpected second chance to recognize new areas with wilderness characteristics. These newly recognized wilderness resources can now be considered for protection through land use plans.

Trespass Reclamation in Wilderness Study Areas

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Oral Presentation Key words: Reclamation, Wilderness

The National Landscape Conservation System (NLCS) of the BLM is committed to responsible management of Wilderness resources through monitoring, maintenance and, where necessary, reclamation of intrusions. Since its inception in 1964, the Wilderness Act set policy, definitions, acceptable and prohibited uses and special provisions regarding lands that qualify for protection in the Wilderness system. Wilderness Study Areas (WSA's) are additional lands that Congress has not acted on and are managed to a non-impairment standard until such time Congress makes a final decision. The Rock Springs Field Office manages 13 Wilderness Study Areas covering 224,265 acres. In Wyoming the WSA's have existed since 1991 and during that time these WSA's have seen an increase in vehicle trespass. This has resulted in damage to these sensitive and fragile areas. This paper details how that trespass is discovered, evaluated and plans to repair the damage.

Restoration and Management of Wilderness and Wilderness Study Areas on BLM Managed Lands in California with the Student Conservation Association (SCA) WILDCORPS Youth Crews

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Oral Presentation
Key words: Restoration Ecology, Improvement of Resource Conditions in Wilderness, Wilderness Study Areas, Outreach, Youth

With passage of the 1994 California Desert Wilderness Protection Act and other wilderness legislation in California, the U.S. Congress established 87 wildernesses on BLM administered public lands in California. Many of these lands were working landscapes that supported mining, livestock grazing, and water conveyance. User-created OHV recreation routes also crossed into newly-designated wilderness and wilderness study areas. Over the past 10 years, in partnership with the Student Conservation Association, and the California Department of Parks and Recreation, Off Highway Motor Vehicle Recreation Division, the BLM has focused on restoration of vehicle routes to natural contour and vegetation within wilderness and wilderness study areas. Restoration has reduced vehicle travel and accelerated natural regeneration of native shrub and forb species and improved resource conditions within wilderness and wilderness study areas.

The BLM completed this restoration through a cooperative agreement started in 1999 with the SCA and established a youth Wilderness Corps. The SCA corps was renamed WildCorps in 2007 and is a statewide strike team that uses primitive skills to manage and restore wilderness characteristics and conserving, protecting, and restoring other NLCS lands in the California. This presentation will share examples of successful restoration work and the partnership with the SCA. The WildCorps program provides young people from across the country the unique experience of living and working in hands-on serviced on the land. They support the mission of the BLM and help create the next generation of conservation leader because their experience instills a deep connection to the land.

Rocks, Islands, and Isolation: Challenges and Success

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Poster
Key words: Wilderness Character Inventory and Management

Rocks and Islands pose an interesting challenge regarding the size criteria for Wilderness Character Inventory and management. In this poster session the team will share their experiences related to two dynamic and exceptional locations wrestling with the evaluations and the ability of visitors to find solitude from the outside world versus from each other. The team will also share challenges and success stories relating to management of rocks and islands with high visitor exposure to remote locations.

The Contribution of Wilderness Character to Understanding Wilderness in the NLCS

PETER LANDRES[1]
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Oral presentation
Key words: Monitoring, Decision Making

This presentation will review how the "Keeping it Wild" interagency strategy for monitoring trends in wilderness character can help BLM managers understand the breadth and depth of wilderness inside the NLCS. This presentation address how monitoring wilderness character can assist BLM staff in making informed decisions about difficult and value-laden issues, such as whether ecological restoration in response to climate change should be conducted inside NLCS wilderness.

Management and Planning

Beyond Multiple Use: Conservation Highlights in Land Use Plans for the First BLM National Monuments

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[1]The Wilderness Society, Denver, CO
[2]The Wilderness Society, Denver, CO

Oral Presentation
Key words: Land Use Planning

Over the past decade, BLM has been grappling with the question of how best to manage and plan for protecting the values and priority uses of national monuments. Planning efforts have been undertaken pursuant to the establishing proclamations and FLPMA, with mandates that can seem to be in conflict. Since many of these plans were drafted with no comparative model, BLM was forging a new path in interpreting proclamation language and helping to sculpt the NLCS (this is especially true of the Grand Staircase-Escalante National Monument, which finished its RMP months before the formal creation of the NLCS in 2000).

Shifting how BLM thinks about land uses during planning is no easy feat and there are undeniably many provisions that miss the conservation mark. However, looking back, it is important to recognize cases where BLM used innovation and solid science to rise above traditional notions of multiple use management. This presentation will highlight instances in land use plans for BLM national monuments where conservation measures were built into the land use planning process that clearly go beyond what is required by the FLPMA multiple use mandate and rise to the call of protection from the monument proclamations and NLCS vision. This presentation will also provide a jumping off point for discussion of how these plans will inform ongoing and future planning and management for BLM national monuments.

Is Commercial Livestock Grazing Compatible with Protecting Objects of Biological Interest in the Cascade-Siskiyou National Monument, Southwest Oregon?

DOMINICK A. DELLASALA[1] and Brian R. Barr[1]
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Oral Presentation
Key words: Livestock Grazing, Proclamation

The Cascade-Siskiyou National Monument, southwest Oregon, was established in June 2000 for its nationally outstanding biodiversity. The Bureau of Land Management (BLM) is legally required to oversee the Monument under terms specified in the Monument's authorizing Presidential Proclamation. Specifically, the proclamation mandates BLM to: (1) "study the impacts of livestock grazing on the objects of biological interest with specific attention to sustaining natural ecosystem dynamics;" and (2) "should grazing be found incompatible with protection of biological interest, the Secretary shall retire the grazing allotments pursuant to applicable law." In response, we assembled an inter-disciplinary team of researchers from universities and private institutions to conduct a series of taxa studies on livestock grazing within the Monument from spring through fall of 2003-06. The studies were conducted in collaboration with BLM, which also conducted its own studies. Researchers used a null hypothesis approach to test the proclamation mandate and an experimental design consisting of paired high and low utilization plots widely distributed across the Monument. Based on findings across several taxa, there was sufficient evidence to reject the null hypothesis that grazing is compatible with protection of the Monument's unique species and communities. High grazing utilization plots had: (1) significantly lower levels of biomass and abundance of certain small mammals, including prey species important to the northern spotted owl; (2) fewer long-distance migrants and shrub-nesting birds; (3) less butterfly species that feed on grassy host-plants; (4) significantly higher temperatures and lower dissolved oxygen concentrations in small springs; and (5) higher levels of degradation along stream and riparian areas. Areas excluded from livestock grazing by BLM for extended periods showed signs of recovery, particularly in riparian areas. Our findings reflect one of the most comprehensive grazing studies conducted on BLM managed lands and a scientific method for testing specific proclamation language.

Wildland Urban Interface – A Strategy for Reducing Fire Risk in the Canyons of Ancients National Monument

LINDA FARNSWORTH[1] and Allen Farnsworth[2]
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[2]NPS Mesa Verde National Park, Mesa Verde, CO

Poster
Key words: Preservation, Management

This poster illustrates how fire managers, resource specialists, and archaeologists are working together on the Canyons of the Ancients National Monument to prioritize and develop fire protection and fuels reduction strategies for archaeological sites that are most vulnerable to high intensity fire. The poster shows some of the strategies that have been implemented to protect important archaeological sites in the Monument; and illustrates how the BLM is working with adjacent private landowners to mitigate fire risk in the urban interface.

Incorporating Historic Data into Current Research: Practical Steps toward Science Based Management

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Oral Presentation
Key words: Planning Management, Climate change, Historic Data, McInnis Canyons National Conservation Area

With global climate change altering ecosystems, the need for better communication between managers and scientists is paramount. Here we look at a practical example that strives to integrate management and science by using a management decision as a starting point for a scientific experiment. In this manner we can better understand the study ecosystem while determining the effectiveness of management actions. In addition, we use historic management data to help define the goals of the study from both a management and scientific perspective, improve our study design, and refine our study hypotheses.

In 2010 we will initiate a study on the survival of native plant species from seed in an area previously seeded with crested wheatgrass (*Agropyron cristatum*). This project stems from a management project to improve sage grouse habitat within McInnis Canyons National Conservation Area. We identified two study sites that had been monitored for rangeland health by the Bureau of Land Management (BLM) since 1990 near our treatment areas. From past monitoring data we were able to identify three dominant plant species (crested wheatgrass, broom snakeweed (*Gutierrezia sarothrae*), and sand dropseed (*Sporobolus cryptandrus*) that showed significant changes (based on χ^2 tests with the assumption of no change between sampling years). We also found stable rates of litter and bare ground at both sites. This information was used to refine our initial hypotheses and study design. In addition we identified some considerations for using historic data including: identifying intrinsic and extrinsic limitations of historic data and identifying how to relate past data sets to proposed data sets, qualitatively or quantitatively. By working to practically integrate science and management, we can move towards the ideal of scientifically informed ecosystem management.

What Part Art and What Part Science? The Legal Role of Science in National Landscape Conservation System Management

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Oral Presentation
Key words: Law and Science

As we reflect on the history and future of research and science throughout the BLM National Landscape Conservation System, we should also consider what role, as a legal matter, research and science play in NLCS management. This presentation will outline how research and science are integrated by law into NLCS management. The presentation will also examine the role that science plays in litigation concerning NLCS management. We know that, with the importance of NLCS units to the public, conflicting public objectives for these units can lead to litigation. While it is well-established that agencies may rely on the expertise of agency resource experts, how has this, as a practical matter, played out in legal cases concerning management of NLCS units such as monuments, wilderness, and wild and scenic rivers? In this presentation, we will follow an intrepid scientist through the different legal NLCS legal designations and discuss the role of science in managing different activities. The presentation will seek audience participation in discussing ways to best integrate science into decision making. The presentation will conclude with discussion of some leading legal cases that illustrate scientific issues in NLCS management.

National Monuments in a Regional Economic Context: Case Study of the Carrizo Plain National Monument

MICHELLE HAEFELE[1], Nada Culver[1] and Alice Bond[1]
[1]The Wilderness Society

Oral presentation
Key words: Economics, Rural West

Research by the Sonoran Institute and others demonstrates that economic growth in the rural West is highly correlated with the presence of protected public lands and other supporting factors, including transportation and communication infrastructure and proximity to larger metropolitan markets. This presentation expands upon this correlation and applies a set of Regional Asset Indicators to the economic region surrounding the Carrizo Plain National Monument. These indicators measure diverse community characteristics and include the presence of human amenities (such as scenery, healthcare and restaurants), skilled workers, innovators and entrepreneurs, as well as the capital and infrastructure to support them.

An evaluation of the income and employment trends of the regional economy and the relationship between those trends and the designation of the Carrizo Plain National Monument will also be discussed.

A Summary of Livestock Impact Studies on Objects of Biological Interest within the Cascade-Siskiyou National Monument, Southwest Oregon

PAUL HOSTEN[1], Evan Frost, Gene Hickman, Frank Lang, Jeannine Rossa, Dulcey Shuster and Henry Whitridge
[1]National Park Service, Kalaupapa NHP, Kalaupapa HI

Oral Presentation
Key words: Livestock Studies, Vegetation Management

Studies of livestock impacts on “objects of biological interest” within Cascade-Siskiyou National Monument (CSNM) focus on the non-conifer portion of landscape where most livestock forage is located. We found that recent livestock management favored noxious weeds and strongly influenced aquatic macro-invertebrate composition, riparian vegetation, *Calochortus greenei* (a special status plant species), and elk (*Cervus canadensis*). Strongest livestock impacts as measured by statistical significance were observed for shorter-lived organisms (weeds and macro-invertebrates), concentrated in riparian areas. In addition to livestock impacts, other historic disturbances that continue to shape the landscape include the removal of beaver (*Castor canadensis*), scarifications (removal of woody overstory vegetation), and non-native seed applications. Recovery and expansion of wetlands in areas of current beaver activity indicate that historic extirpation of beaver had an extensive impact on the landscape. Following the removal of livestock, the reintroduction and protection of beaver is the most easily implementable management action with favorable outcome on the landscape. Scarifications from the 1950s onwards are notable for their conversion of the herbaceous understory to non-native plants - not the intended reduction of fuels or improvement of forage for wildlife and livestock. Subsequent seed applications introduced over 50 non-native species to the CSNM, some of which have expanded to unmanageable proportions (*Poa bulbosa*) or will require great expense to control (*Phalaris arundinacea*). Our historic research indicates vegetation management actions can leave undesired long-term impacts on the landscape.

Protecting Cultural Landscapes and Managing Multiple Use

LOUANN JACOBSON[1]
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Oral Presentation
Key words: Preservation and Multiple Use

Canyons of the Ancients is a component in the Bureau of Land Management's National Landscape Conservation System, emphasizing the protection of cultural and natural landscapes rather than fragmented ecosystems and individual cultural resource sites. In addition, the Monument was established with the intent of continuing multiple use. Management requires balancing conflicts between valid existing rights for fluid mineral development, protecting a landscape with over 100 sites per square mile, and honoring Native American Tribal affiliation with monument cultural and natural resources. This presentation, using a case study, will review conflicting management mandates and the process for resolution of these conflicts.

The case study project went beyond typical National Historic Preservation Act Section 106 procedures and applied cultural resource research methodology (including large block inventory and subsurface testing) to protect cultural resources and determine the potential for presence or absence of subsurface cultural material.

Planning for Climate Change in the NLCS

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Oral Presentation
Key words: Climate Change, Conservation, Management, Adaptation

The National Landscape Conservation System (NLCS) provides a unique opportunity for the Bureau of Land Management (BLM) to prepare for climate change using best available science to ensure that the resources for which this special conservation designation was created are preserved as intended. We recently reviewed a sample of 14 Resource Management Plans (RMPs) for their approach to planning for climate change. Only one mentioned climate change. Some of the management actions prescribed in the plans are appropriate pieces of a climate change strategy, while many others will result in the degradation of natural and cultural resources intended for conservation. Some of the appropriate actions include road closures and obliteration, removal of cattle from riparian areas and other sensitive habitats, restoration of habitat connectivity and floodplains, reclamation of degraded areas with native seed, acquisition (or buy-outs) of water, mineral, and energy rights/leases, and invasive species detection and control. Many other actions, however, are expected to act synergistically with climate change to increasingly reduce the resilience of natural and cultural resources to climate change, including grazing, oil and gas development, road development, facilities development, and OHV travel. Other prescribed actions may simply be ineffectual under climate change. Examples include reintroductions of fish and wildlife species dependent on historic climatic conditions, reseeding with vegetation that is no longer viable, maintaining specific vegetation distributions, and maintaining wildlife ranges and fire regimes established under historic climatic regimes. Finally, most plans lack a rigorous adaptive management approach that is vital under climate change. Climate change is a new challenge for BLM land managers and planners. Yet if they fail to plan for this challenge, many units will experience accelerated degradation of resources that the BLM has been mandated

to protect. We provide step-by-step guidance for NLCS planners to incorporate climate change into the planning process.

The San Pedro Riparian National Conservation Area

JIM MAHONEY[1], Heather Swanson[1], Marcia Radke[1] and Paul A. Brown[1]
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Poster
Key words: Globally Important Natural and Cultural Resources

In November 1998, under Public Law 100-696, Congress established the San Pedro Riparian National Conservation Area. The Bureau of Land Management was charged to manage this first such 'riparian' conservation area in a manner that conserves, protects, and enhances the riparian area and the aquatic, wildlife, archeological, paleontological, scientific, cultural, educational, and recreational resources of the conservation area. This presentation will highlight the globally important natural and cultural resources for which the area was designated, and the challenges faced by the agency and the area's stakeholders in meeting the spirit and letter of the enabling legislation.

Off-Highway-Vehicle Use and its Impact on Wildlife in the Gunnison Gorge National Conservation Area and Surrounding Area

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Oral Presentation
Key words: Collaboration, Wildlife, Off Highway Vehicle Use

In 2004, USGS scientists joined together with resource specialists from the Bureau of Land Management, National Park Service, National Forest Service and Colorado Division of Wildlife along with ranchers and recreational group representatives to investigate impacts of Off-Highway-Vehicles (OHV) on wildlife movement. The study area is composed of private (approximately 27%) and public (approximately 73%) lands managed by collaborating agencies. The Gunnison Gorge National Conservation Area lies totally within and makes up a significant portion of the study area. The species of initial interest were Rocky Mountain Elk and Gunnison Sage Grouse. During the initial phase, 50 elk were collared with GPS collars to record movements and habitat use patterns in relationship to intensity of use generated by OHV traffic. A twenty-site OHV monitoring network was also developed to simultaneously monitor timing, type and intensity of use generated by OHV traffic. We have collected over 200,000 vehicle counts and over 35,000 elk locations. In compiling and analyzing data from this work the group learned that daily OHV use peaked within a two to three hour range for all sites, the overall volume of use varied by site on an annual basis, and OHV "spawning" is an actual phenomenon. Regarding wildlife, results indicate that there is a threshold of OHV use, i.e. vehicles per hour at which elk respond to by moving further away from roads or moving on to private lands. Initial results indicate that with controlled motorized use, National Conservation Areas provide wildlife refuge without forcing them to move onto private lands. This project will continue for a minimum of three more years with wildlife emphasis shifting from elk to Gunnison Sage Grouse. Preliminary lek

analysis has already been accomplished and will be followed by GPS tagging and habitat analysis for Gunnison Sage Grouse along with continued vehicle monitoring.

Endangered Species Management and Scientific Endeavors on the Carrizo Plain National Monument

KATHY SHARUM[1] and Larry Saslaw[1]
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Oral Presentation
Key words: Outdoor Laboratory, Endangered Species, Grassland

Carrizo Plain National Monument is a unique, undeveloped portion of what was once a vast ecosystem covering millions of acres in California. At just over 200,000 acres, the Bureau of Land Management manages the Monument in coordination with The Nature Conservancy and the California Department of Fish and Game. It is an area recognized for its exceptional biological diversity and is home to over 40 special status species of animals and 20 special status species of plants. On its north end the 3000 acre alkali lake, Soda Lake, can support thousands of birds in a rainy season and represents one of the rarest plant communities. The plains (or grasslands), are bordered by two mountain ranges and the entire Monument is bisected by the San Andreas Fault. Over the last twenty years, this protected area has proven to be an outstanding outdoor laboratory where research has ranged from studying fairy shrimp, beetles and moths to ancient dunes and earthquake frequency. The Carrizo's uniqueness has also made management of the area a challenge in light of its diversity, endangered species protection, historical uses of the land and increased visitation by the public. This presentation will introduce highlights of a number of research projects while describing some of the challenges for management and the innovative ways used to overcome them.

Past, Present and Future – Science on Grand Staircase-Escalante National Monument

CAROLYN Z. SHELTON[1] and Melanie Boone-Reznick[2]
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[2]Grand Staircase-Escalante Partners, Kanab, UT

Oral Presentation
Key words: Collaboration, Science,
Grand Staircase-Escalante National Monument (GSENM) was established in 1996 to protect the scientific and cultural resources within its boundaries. The Proclamation creating the Monument specifically states:

> A comprehensive and integrated research and science program will ensure that scientific resources are not only available for current research opportunities, but that certain scientific resources are preserved in place for future study. Presidential Proclamation, 6920, 1996.

The Monument Management Plan, completed in December 1999 and adopted in February 2000, emphasized scientific study as part of an overall vision for the Monument. Even before completion of the management plan, an ambitious research plan was initiated covering the breadth of resources and an assortment of disciplines. From

1998 to 2002, GSENM spent approximately $1,000,000 per year on agreements to fund roughly thirty projects. Since that time, shrinking budgets have affected the scope of research.

A recent emphasis on science and research government-wide is invigorating a renewed science initiative. As the citizen support organization, Grand Staircase-Escalante Partners (GSEPartners) is embarking on a strategic plan to elevate science research back to its prominence on the Monument – in collaboration with GSENM staff. Partners will promote the "spectacular array of scientific and cultural" research opportunities available on the Monument and work to expand facilities available to encourage such research through their newly created Grand Staircase Institute for Science (GSIS). Partners seeks funding to assist research that will inform management decisions, as well as funds for the Monument's non-renewable archeological, paleontological and geologic resources. Understanding of and appreciation for the Monument will continue through educational and interpretive opportunities of research data such as elementary and high school curricula, a digital library, and special programs.

This presentation will emphasize the collaborative efforts being forged between the BLM and GSEPartners to ensure and enhance critical research on Grand Staircase-Escalante National Monument.

Climate Change and Ecosystem Services: Contribution of Public Lands in the United States

SPENCER PHILLIPS[1], Valerie Esposito[2], Roelef Boumans[2], Azur Moulaert[2] and Jennifer Boggs[1]
[1]The Wilderness Society
[2]Gund Institute for Ecological Economics

Oral presentation
Key words: Climate Change, Economics, Ecosystem Services

Ecosystem service valuation provides a comprehensive framework for considering the contribution of Public Lands to human well-being, as well as how that contribution may change over time due to external stresses. In a warming climate, for example, the level and mix of ecosystem services available from the natural areas present on the federal public lands are likely to change, and evaluation of those changes can help managers plan for the needs of species, systems and landscapes to adapt to a warmer and more volatile climate.
Through a combination of GIS analysis and benefits transfer methods, Philips and his co-authors have assessed current ecosystem service flows for U.S. National Parks, National Forests, Fish and Wildlife Refuges and BLM managed lands, including the National Landscape Conservation system. They have also estimated changes to those service flows under climate change scenarios.

Using conservative assumptions, the overall trend indicates that ecosystem services values are likely to decrease as temperature increases, but the effect is not the same for all ecosystem services or for all areas; more highly protected areas, for example, may experience great changes in ecosystem service value than other public lands. In this presentation Phillips focuses on such estimates for the Public Lands, and discusses the role of these lands in ensuring ecosystem service values in the future.

Land Acquisition in the National Landscape Conservation System

MICHAEL WERNER[1], David Kirk[2] and Ken Mahoney[1]
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[2]The Wilderness Land Trust, Carbondale, CO

Poster or Oral Presentation
Key words: Partnerships, Collaboration, Wilderness

The Wilderness Land Trust has been a partner with the Bureau of Land Management in Arizona for the past five years in all aspects of the process to acquire private lands within areas of the National Landscape Conservation System (NLCS) from willing sellers. By negotiating the acquisition of wilderness inholdings for the BLM, The Wilderness Land Trust has completed significant work that will have lasting benefits for generations to come. During the past three years the efforts have been especially noteworthy, with projects pointed towards the acquisition of inholding lands in the BLM wilderness areas of northwestern Arizona. The consolidation of ownerships has made for more efficient management of the wilderness areas, and has protected these lands into perpetuity. Such victories are especially important, as these are lands that rest within the shadows of the outward expansion of nearby towns and cities. A most noteworthy acquisition involved the recent final Secretarial approval of the Hells Canyon Wilderness inholding acquisition that occurred with funding from the Federal Land Transaction Facilitation Act program. The 640-acre property had been the only remaining private inholding within Hells Canyon Wilderness (located near Phoenix), and it had been a BLM acquisition target for more than 20 years. Without the efforts of The Wilderness Land Trust, the acquisition of this integral piece could not have occurred. Preserving the core of the wilderness area eliminates the threat of future development and access issues within the area. With this acquisition effort, and others like it, it is clear that The Wilderness Land Trust and the BLM have formed a unique partnership that is dedicated to accomplishing lasting work that will be experienced by America's next generations.

Visual Resources and Aesthetics

A Visual Tour of Cedar Mesa - The Unifying Force of the Visual Arts in Protecting Public Lands

ROMMES, DONALD J.[1]
[1]Landscape photographer

Oral Presentation (multimedia)
Key words: Photography, Conflicting Interests, Landscapes, Common Ground

The diverse areas included in the NLCS share one common feature - the beauty of the landscape. As people with different interests and values discuss ways to study, use, and preserve these lands, conflicts may arise. At those times, it is especially important to be reminded of what it is that unites the parties - their love for the land. Because of its evocative power, photography can inspire and motivate: reminding everyone of their shared values in the midst of conflicting interests. This presentation will briefly highlight some conflicting interests at play in Cedar Mesa, Utah, show gorgeous photography that reminds all parties why the land is worth fighting for, and present ideas on how such photography can be a unifying force in finding common ground to build upon.

Presenting BLM's Guidelines for a Quality Built Environment

ALLYSIA ANGUS[1]
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Oral Presentation
Key words: Social Sciences, Sustainable Facility Planning and Design

BLM's Guidelines for a Quality Built Environment (GQBE) addresses how to create sustainable, attractive, and functional facilities. It establishes easy-to use design guidelines for a variety of different facility types ranging from visitor centers and fire stations to trailheads and campgrounds that are located in diverse settings from desert to forest and from primitive backcountry sites to urban locales. The document integrates guidance from related federal programs and directives while providing examples of quality BLM projects for reference and guidance. It presents a process for planning and design to be followed by BLM staff, contractors, and volunteers that will ensure BLM's built environment is reflective of the agency's concern for the environment, the public, and its employees.

With their high profile and emphasis on public interaction, NLCS units provide unique opportunities for implementation of the GQBE. Many NLCS projects are included in the document as examples of BLM's commitment to providing high quality and sustainable facilities. Examples include the visitor centers at Grand Staircase-Escalante National Monument in Utah, recreation site developments at Red Rocks National Conservation Area in Nevada, and the interpretive center at Pompey's Pillar National Monument in Montana.

This effort to enhance BLM's built environment, and concurrently its public image, affirms the agency's commitment to sustainable facilities that support the health, diversity, and productivity of the public lands for the use and enjoyment of present and future generations.

The vision of the QGBE states, that in support of BLM's responsibility to manage diverse landscapes and multiple uses, the agency will provide quality facilities for the public and its employees that are sustainable, attractive, functional, cost-effective, and responsive to place and setting. This session will highlight how that can be accomplished, and how those charged with developing facilities in NLCS units can play a critical role.

Visual Resource Management (VRM) Policy and Stewardship role in Landscape Scale Multiple-use Management

JOHN MCCARTY[1]
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Oral Presentation
Key words: Visual Resource Management Policy, Stewardship, Multiple-use

BLM's Visual Resource Management (VRM) program is a systematic approach to managing the human concern for scenery and public acceptance for visible change to the natural landscape. Established criteria and procedures for inventorying visual values guides the process and provides a framework for managing these values through defining tolerance thresholds for landscape change.

This presentation will articulate the VRM policy and stewardship role in landscape scale multiple-use management within the National Landscape Conservation System.

Visual Resource Management and the Science Behind the Scene - Effective Application of the VRM Best Management Practices

JOHN MCCARTY[1]
[1]Bureau of Land Management, Washington Office, Washington, DC

Oral Presentation
Key words: Interdisciplinary Collaboration, Procedures, Mitigation, Visual Restoration

While visual values are an expression of human appreciation of the aesthetics of place and setting, the management of these values is rooted in science and technology. Successful management and protection of the visual environment can only be achieved through a systematic analysis and thoughtful application of scientific principles.

Visual Resource Management is playing an increasingly important role in balancing the demand for natural resource development with the public appreciation of the expansive natural qualities of these public lands and protection of its scenic values. Success depends on drawing from the BLM's array of natural resource science expertise in a team approach toward stewardship of the visual environment.

This presentation will demonstrate the powerful results that can emerge from integrating the science based disciplines into collaborative management of the visual environment.

Visual Resource Management Research – the Decade Ahead

ROBERT SULLIVAN[1]
[1]Argonne National Laboratory, Landscape Architect/Program Manager, Argonne, IL

Oral Presentation
Key words: Management, Scenic and Aesthetic Values

Visual resource management has come to the fore with the burgeoning development of renewable energy. Looking forward this paper reviews current visual resource research exploring the possibilities for managing the scenic and aesthetic values of the National Landscape Conservation and beyond.

Visual Resource Management – GIS and Computer Visualization Technology

ROBERT SULLIVAN[1] and Rob Sweeten[2]
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[2]Bureau of Land Management, Utah State Office, Salt Lake City, UT

Oral Presentation
Key words: GIS, Computer Visualization Tools

Visual resource management relies on GIS and computer visualization technology. These powerful tools are used for inventory, land use planning, and analysis for defining impacts and protection visual values associated with the BLM's treasured landscapes. This presentation will provide examples of how this technology is informing decision making in the BLM.

The Use of Color and Camouflage to Mitigate Visual Impacts

KATE SCHWARZLER[1], John McCarty[2] and Tom Lahti[3]
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Poster
Key words: Visual Mitigation

Federally administered public lands are experiencing unprecedented development and use pressures from environmental incentives for developing renewable energy resources (solar, wind, and geothermal) and energy transmission, as well as from more traditional activities including transportation corridors, communication sites, recreation, livestock grazing, mineral, and other forms of development. Growing land-use demands have the potential to significantly modify the character of the natural landscape, placing increasing pressure on the protection of scenic values.

Using color for visual mitigation, combined with the manipulation of texture, line, form, and scale can be an effective, relatively simple, and cost-effective tool for visual mitigation. Modifying the elements of *color, line, form, texture,* and *scale* of visually disruptive structures so that they conform to the visual characteristics of the surrounding natural environment results in the structures appearing to visually recede in the landscape. While they may not disappear entirely, they no longer become the focal point. The goal is to effectively minimize color contrast between the development and surrounding landscape.

This poster presentation will demonstrate two techniques for integrating color into visual mitigation practices. The first and most common technique for blending facilities into the surrounding landscape is the application of a single color of paint. This type of application is most effective in the middle-ground distances, one to five miles from the viewpoint.

The second technique is the use of camouflage, where multiple colors are applied in an organic pattern, breaking up the form of an object. The colors of the pattern repeat the colors seen in the surrounding landscape—including the shadows—creating the illusion that the object is part of its surroundings, both positive and negative space. Camouflage applications appear to be most effective in the foreground, between 100 yards and 1 mile from the viewpoint.

Recreation

Front Country Visitor Study for Grand Staircase-Escalante National Monument

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Oral Presentation
Key words: Front Country Visitors, Visitor Characteristics and Use, Management

This study was conducted during the 2004 visitation season by the Institute for Outdoor Recreation and Tourism (IORT), Utah State University, with the purpose of providing baseline data concerning front country recreation use and visitor characteristics, images, and perceptions of Grand Staircase-Escalante National Monument (GSENM); and to investigate the relationship between visitation and other GSENM values, the GSENM travel management plan, and local community services.

From March through October, 2004, an intercept survey was randomly administered at 24 locations in the Front Country and Passage Zones of the GSENM; contact was made with 2,306 visitors, and of this number, 2,062 visitors agreed to be interviewed and completed the intercept survey for a response rate of over 89%. One of three versions of the intercept survey was administered depending on the type of survey site: recreation/scenery sites (n = 573); visitor centers (n = 602); and scenic overlooks along Highway 12 (n = 887). A mail survey was mailed to 1,148 visitors who agreed to complete it; 766 visitors returned completed mail surveys for a response rate of 68%. Because of the random nature of data collection effort and very acceptable visitor response rates, the results of the study are generalizable to all front country visitors to the GSENM during the 2004 visitation season.

Visitors to the GSENM came from throughout the United States and the world, with international visitors representing almost one-quarter of front country visitors. There appears to be an ongoing "designation effect" as slightly more than sixty percent of visitors were visiting the GSENM for the first time, and about 85% of all visitors would have visited between 1996, the year of the GSENM's designation, and 2004. Results and key findings of the Front Country Visitor Study for the GSENM related to visitor characteristics and management will be presented.

Generating Useable Recreation Customer Assessment Results

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Oral Presentation
Key words: Useable Recreation Customer Assessments

Various customer assessment methodologies have been employed to get at what really matters to recreation-tourism customers, to participants and affected community residents alike. Professional understanding of what really matters to these publics has dramatically improved in recent years. Advancements in recreation science have further demonstrated the importance of understanding what kinds of setting characteristics and service delivery systems are required to achieve such desired results.

Despite these scientific advances, generating practically useable assessment results for management and marketing has been challenging. Two of these challenges are particularly significant. The first has been establishing a useable and consistent customer assessment response context that relates desired recreation products to specific land units and recreation activities. The second challenge is finding a way to display integrated assessment results for all key recreation product components by each identifiable customer market segment.

This presentation explores collaborative efforts of Mesa State College and BLM's Grand Junction Field Office to identify and display practical useable customer preference results for key recreation product components by each of several distinctively different recreation-tourism market segments. In the past, these distinctions have been based principally on recreation activities. Because ultimate recreation results (i.e., experiences and other

beneficial outcomes) are more important to customers than is simple activity participation, practitioners need to be able to match up customer desires for recreation's beneficial results with whatever management units are best suited to producing them. At the same time, they also need to know how the setting and service environments upon which customers' desired results depend vary across differing customer segments and by different recreation management units. Collaborating partners found a practical way to define the different customer market segments interested in each recreation management unit in terms of their differing outcome desires, and to display the differing setting preferences of each as well. The presentation further explores how the BLM and collaborating recreation-tourism service and infrastructure providers are using results to decide who to serve, what kinds of recreation to provide, and how to manage essential setting and service environments.

Annual Visitor Satisfaction Survey Results and Implications for the NLCS

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Oral Presentation
Key words: Visitor Satisfaction

The Bureau of Land Management in cooperation with the University of Idaho-Park Studies Unit has conducted an annual visitor satisfaction survey on BLM managed lands since 2005. Over the last five years this survey has included 36 different NLCS sites. Information gathered from these efforts includes important social science data that can help BLM better understand and map the human habitat of the west. Additionally, by equipping managers with demographic data, visitor satisfaction figures, and reasons for destination choice, they have data to support land management decisions. This presentation will outline the current findings and discuss how the annual information collection can help the NLCS achieve the goals outlined in the NLCS 10th Anniversary Public Outreach Plan, and beyond.

A Physical and Social Study of Mountain Bike Use on Five Segments of the Continental Divide National Scenic Trail in Colorado

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Oral Presentation
Key words: Continental Divide National Scenic Trail, Hiking, Leave No Trace, Limits of Acceptable Change, Mountain Biking, Multiple Use, Social Conflict, Trail Management

This capstone reviews uses of the Continental Divide National Scenic Trail. Policies governing use of the trail appear to be ambiguous, especially regarding mountain bicycles. Mountain biking has grown since the trail was created, but is not fully addressed in existing or proposed policy. 382 people on five segments of the trail in Colorado were interviewed for this capstone. Mountain bikes, hiking, and motorized recreation were observed uses. User conflict, overcrowding, degraded recreation experiences, or user displacement was not reported. User satisfaction was high and most would return. Interviewees requested increased public involvement and

recognition of user needs in setting policy. Trail degradation occurs, but is unassociated with any particular use. Recommendations for trail improvement and maintenance are presented.

It's All About Asking Questions Part 1: Recreation Impact Inquiries in the Backcountry on BLM Managed Lands

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Oral Presentation
Key words: Recreation Impacts, Assessments, Ecology

The foundation of all research lies in inquiry and investigation of data or other material to determine appropriate responses and, perhaps, future actions. Recreation Impact Assessment is based on applied research with field-based data collection to determine longitudinal trend analysis in the protection and longterm preservation of recreation sites. This presentation will discuss typical and atypical research questions for Backcountry Use (backpacking, hiking, river travel) in Southwest BLM monuments. The presentation will explain the impact assessment approach used to answer these special research questions and will provide examples of data collected. In addition, indicator variables for dealing with unique research questions via physical impact assessment will be highlighted.

It's All About Asking Questions Part 2: Recreation Impact Inquiries in Dispersed Recreation on BLM Managed Lands

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Oral Presentation
Key words: Recreation Impacts, Assessment, Ecology

The foundation of all research lies in inquiry and investigation of data or other material to determine appropriate responses and, perhaps, future actions. Recreation Impact Assessment is based on applied research with field-based data collection to determine longitudinal trend analysis in the protection and longterm preservation of recreation sites. This presentation will discuss typical and atypical research questions for Dispersed Recreation (vehicle camping and dispersed travel including OHV use) in Southwest BLM monuments. The presentation will explain the impact assessment approach used to answer these special research questions and will provide examples of data collected. In addition, indicator variables for dealing with unique research questions will be highlighted.

Recreation Research in BLM Alaska's NLCS Units

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Poster
Key words: Recreation, Alaska

The poster would summarize the body of recreation science completed in advance of NLCS-related Resource Management Plans for making the four required land use allocation decisions for Recreation in the BLM 1601 Appendix C Handbook. The Cooperative Ecosystems Study Unit agreement with the University of Alaska will be highlighted in developing the research theory, design and implementation. The practical utilization of the recreation data collected will be demonstrated in forming Supply and Demand Niche Decisions, Outcome-based Management Objective Decisions, Outcome-facilitating Desired Future Setting Decisions, and Outcome-Guided Management Framework Decisions. The case will be made that Outcome-Focused Recreation Management that commits to these RMP land use allocation decisions will better enhance and sustain NLCS values far better than the incomplete experience-based model. It only makes good sense that the legislative allocations for wilderness character, wild and scenic river outstandingly remarkable values, and other enabling legislative direction for naturalness, social and operational settings be carried forth in administrative land use plans as allocation decisions. Leaving such critical setting condition and character to adaptable implementation prescriptions is not a sustainable strategy for delivering quality RecSystem and EcoSystem Services.

Alternative Transportation Systems Inventory for BLM: Potential to Enhance the Visitor Experience and Preserve Resources

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Oral Presentation
Key words: Transportation, Mobility, Visitor Services, Technical Assistance

The Paul S. Sarbanes Transit in the Parks (TRIP) Program, sponsored by the Federal Transit Administration, provides approximately $27 million dollars annually to fund planning and implementation projects for alternative transportation systems (ATS) in parks and public lands. ATS include not only vans and shuttle services but also connections to regional transit systems, regular sightseeing tours, and nonmotorized connections for transportation purposes. The program goals include improvement of visitor access and mobility, reduced congestion and pollution, and conservation of natural and cultural resources. While BLM is eligible to apply for these grant funds, the agency has traditionally not submitted applications over the program's four-year history. As part of a project funded by the Department of the Interior, the U.S. DOT's Volpe National Transportation Systems Center has completed an inventory of existing and potential ATS sites on or connecting to BLM managed lands. Through interviews with BLM managers at the State and Field Office level, the Volpe Center has worked to catalogue existing ATS, identify sites with the greatest potential for ATS, and facilitate the preparation of grant applications in the upcoming grant cycles. The presentation will report on the key findings of the ATS Inventory, including the operational and financial attributes of existing ATS on BLM managed Lands and the successful elements of these systems. The presenters will describe site attributes that indicate the potential to improve the visitor experience or conserve resources through ATS solutions and identify examples of successful TRIP program projects.

Interpretation and Education

Prehistoric Trackways National Monument: From Scientific Journals into the Hearts of the Community

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Oral Presentation
Key words: Interpretation, Education, Partnership

Prehistoric Trackways National Monument was designated in March 2009. It is the 100th National Monument and the 16th under the management of the BLM – NLCS. The trackways in the Robledo Mountains are considered the "Rosetta Stone" of the Paleozoic period by the world's paleontological community, but this Rosetta stone does not easily translate into the hearts of the community at large. There are a few reasons for this. First, the most heavily used entrance into the Monument has been utilized as a quarry, a dumping ground, and a party spot. It does not set the scene for what the typical impression of a Monument is. Second, getting into the Robledos and seeing the scenic desert beauty of the mountains is physically challenging in this rough country. Third, the physical challenge of seeing the desert also goes for the tracks themselves; they are not easily accessible.

How can the community be engaged? From the interpretation and education perspective, a series of questions have arisen. How can the scientific communities' research be made more 'popular' and accessible to people? What are the avenues to engage local interest groups and education facilities? Can collaborations be formed with museums, universities and local schools to help create physical, intellectual and emotional connections through displays, internet links, exhibits, and field trips? This presentation will tour the beginnings of this Monument with the hope of initiating further discussions of additional possibilities for enticing the public's interest in the Monument.

Wild about the Grasslands! At the Historic Empire Ranch, Las Cienegas National Conservation Area

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Poster
Key words: Outdoor Education, Experiential Education

Wild about the Grasslands! is an ecology and ranching heritage outdoor education program designed for youth, Grades 6-8. The Empire Ranch Foundation, in partnership with the Bureau of Land Management, Tucson Field Office, provides two week-long, day camp experiences at the historic Empire Ranch in the heart of the Las Cienegas National Conservation Area (NCA). This unique program aims to *educate youth so that as citizens they understand the value of their natural and cultural resources and have the desire and means to practice sustainable stewardship*. The goals of the program are to:

- Nurture an appreciation of the ecological importance of the Las Cienegas National Conservation Area and cultural heritage of Empire Ranch;
- Discover and stimulate personal meaning and connection to the outdoor environment through nature-inspired art and outdoor recreation activities;
- Promote an understanding of environmental sustainability and stewardship; and
- Develop 21st Century Skills in creative and critical thinking, technology tools, collaboration, and communication by working with master teachers, field scientists, land managers, and local experts.

Through guided hikes and hands-on explorations our summer campers learn about the forces that shape the landscape of the semi-desert grassland and rich ranching heritage that continues today. Our spring campers learn firsthand about the Cienega Creek and Cienega Watershed as a precious resource to support a diversity of plants, wildlife, and its significance to the people who depend on it. Journaling, art, real-science investigation, wildlife monitoring, adobe brick making, cattle branding are just some of the activities used to introduce participants to the biotic communities and historical features. Geocaching and letterboxing, or the use of maps, compass, and GPS to find hidden treasures, is a practical way to introduce students to stewardship and responsible outdoor recreation. Empire Ranch is a member site of Hands on the Land National Network of Field Classrooms.

Seeing is Believing: Connecting people with Resources and Landscapes via Close-Range Photogrammetry

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Oral Presentation
Key words: Photogrammetry, Natural and Cultural Resource Values, Monitoring, Interpretation, Grand Staircase-Escalante National Monument

Developments in Close-Range Photogrammetry, the science of making precise measurements from photographs, offers unique opportunities for monitoring resources and connecting people with the outstanding cultural, ecological and scientific values found in NLCS units. To date this work has been done by photogrammetric specialists. However with their extended and frequent immersion within these outstanding landscapes, Backcountry Rangers and other field personnel are in the perfect position to observe changes in resources and contribute greatly to their monitoring and stewardship.

Throughout the 19th and 20th centuries, photographic art and documentary photojournalism have connected people with real objects and real events in the real world. Humans are visual creatures and "seeing is believing." Using basic photographic equipment and a modest investment of time to learn the processes and techniques, Close-Range Photogrammetry gives field personnel the power to combine the documentary and emotional power of photography with the ability to precisely and scientifically quantify changes to valued resources and landscapes at scales that are meaningful for scientists, resource managers and the general public. Teamed with well-designed interpretive products, Close-Range Photogrammetry may help the public connect with otherwise abstract scientific observations and science-based management. Monitoring applications include:

- vandalism and erosion at dinosaur track sites and prehistoric rock art panels;
- erosion on social trails approaching cultural sites;

- effectiveness of off-highway-vehicle impact rehabilitation;
- changes to cryptobiotic soil crusts; and
- impacts at backcountry and front-country campsites